

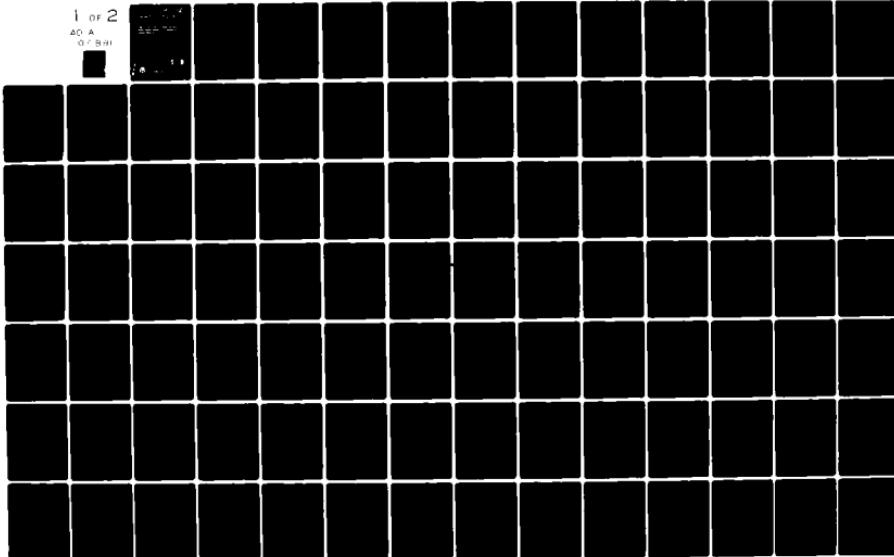
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INDUSTRY VIEWS ON THE ABILITY OF THE U.S. PHOTOVOLTAICS INDUSTRY--ETC(U)  
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REPORT BY THE U.S.

# General Accounting Office

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## Industry Views On The Ability Of The U.S. Photovoltaics Industry To Compete In Foreign Markets.

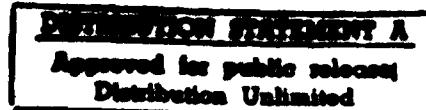
As requested by the Chairman of the Subcommittee on Energy Research and Development, Senate Committee on Energy and Natural Resources, this report presents the views of over 30 companies and experts in the U.S. photovoltaics industry on the competitiveness of U.S. firms in foreign markets and the administration's proposed solar energy budget reductions. It also briefly describes the solar energy programs and activities of France, West Germany, Italy, and Japan, which are the U.S. companies' major competitors in the world market.

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UNITED STATES GENERAL ACCOUNTING OFFICE  
WASHINGTON, D.C. 20548

INTERNATIONAL DIVISION  
B-204650

The Honorable Pete V. Domenici  
Chairman, Subcommittee on Energy  
Research and Development  
Committee on Energy and Natural  
Resources  
United States Senate

Dear Mr. Chairman:

Subject: Industry Views on the Ability of the  
U.S. Photovoltaics Industry to Compete  
in Foreign Markets (ID-81-63)

This report is in response to your letter of June 3, 1981, requesting information on the effects of proposed budget changes on the competitiveness of the U.S. photovoltaics industry in the world market. That information, contained herein, was obtained largely from interviews (1) with individual experts, (2) with officials of U.S. companies involved in the photovoltaics industry, the Solar Energy Industry Association (SEIA), the Solar Energy Research Institute (SERI), the Departments of Energy (DOE) and State, and U.S. Embassies in Italy, France, and West Germany, and (3) with several French Government officials.

Our sample of U.S. companies and individuals represents a broad spectrum of photovoltaic firms and other knowledgeable parties. Using lists of companies and individuals active in the U.S. photovoltaic industry compiled by SERI, SEIA, and DOE, we visited companies and persons listed in two major geographic regions having the highest concentration of such companies--the Northeastern seaboard from Maryland through Massachusetts and the California-Arizona region--as well as the Denver, Colorado, and Salt Lake City, Utah, areas. We selected a cross-section containing small and large companies, companies owned by oil companies, and those not owned by oil companies, companies actively manufacturing and marketing photovoltaic products, and those still in preproduction research and development, and companies involved in the industry only through Government-funded research and development (R&D). Appendix I provides a brief background on each company and individual interviewed, including the nature of their involvement in the photovoltaics industry.

In conducting the interviews with individual experts and representatives of private industry, we used a prepared list of questions which we mailed in advance and then structured the discussions around the questions. We then gave each individual the opportunity to review and correct his comments in writing.

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Their comments are presented and summarized in Appendix II. Statements by interviewees who consented to speak for attribution are attributed to the appropriate company and/or individual. Statements of those who preferred not to speak for attribution are included under "Other Comments."

Appendix III describes the potential effects of the administration's proposed budget reductions on joint photovoltaic projects operating or planned under international agreements. This information was collected from DOE and SERI. Appendices IV through VII provide brief descriptions of the solar energy programs and activities of France, West Germany, Italy, and Japan. France, West Germany, and Japan are generally considered by the U.S. companies we visited as their principal competitors in the international market, and Italy has plans to become a strong competitor. Appendix IX lists the companies, organizations, and individuals that we interviewed during this survey.

In reading this report, one should note that our interviews were conducted during April and May of 1981, shortly after the administration had proposed substantial solar energy budget reductions. (See app. VIII.) The photovoltaic budget was slated for a 61.1 percent reduction for fiscal year 1982, to \$62.9 million; and the International Solar Energy Program was slated for a 69.1 percent reduction, to \$4 million. Therefore, the views reported herein reflect reactions to these substantial proposed reductions.

As requested by your staff, we did not obtain official agency comments in order to meet the requested report target date. Also, as requested by your office, we are sending copies of this report at this time to each member of the Senate Committee on Energy and Natural Resources and to each of the private companies, individuals, and U.S. Government agencies that we contacted during the review. We plan no further distribution of this report until 30 days after its date of issuance, unless you publicly announce its contents earlier. At that time we will send copies to other interested parties and make copies available to others upon request.

Sincerely yours,



Frank C. Conahan  
Director

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APPENDIX I

BACKGROUND ON COMPANIES AND INDIVIDUALS INTERVIEWED (note a)

Acurex Corporation  
Mountain View, California

Acurex Corporation provides engineering services and manufactures various semiconductor devices, including microprocessor-based data acquisition systems, control wireless data coupling systems, and other processing equipment. Acurex performs its commercial solar energy work through Acurex Solar Corporation, a joint venture with Phillips Petroleum Company formed on April 25, 1980. Government solar energy work is still done by Acurex Corporation. Acurex Solar Corporation designs, constructs, and operates photovoltaic (PV) and other types of solar energy systems. It does not manufacture PV cells. During 1980, 95 percent of Acurex Solar's photovoltaic work came from Government-funded projects; only 5 percent came from the private sector.

Acurex Solar's major target in its efforts are large industrial and utility applications of PV and solar thermal systems, both in the domestic and foreign markets. Its sales in these areas for each of the past 3 years has been about \$8 million; it projects about the same volume for 1981.

Anthony Adler, President  
Solar Investors Associates  
New York, New York

Mr. Adler is the president of a private joint capital fund called Solar Investors Associates, which has five partners. He is also Vice President, Investment Banking Group of Muller & Company, a member of the New York Stock Exchange. With Muller & Company, his responsibility is the energy area, mostly renewable energy endeavors. Muller & Company has underwritten three public solar energy companies--American Solar King, Intertech Solar, and Applied Solar Energy Corporation. Muller has also underwritten the formation of an alcohol fuels company. Muller is also a financial consultant and has participated in other offerings of flat plate thermal and photovoltaic companies when they went public.

AMETEK, Inc.  
Paoli, Pennsylvania

AMETEK is a diversified industrial manufacturer whose production of capital goods and components for consumer products makes possible its participation in both the capital equipment and consumer goods markets. AMETEK serves these markets through four operating groups: Precision Instruments, Process Equipment,

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a/Information in this appendix is from annual reports, other public documents, and interviews with key company officials.

## APPENDIX I

**Electro-mechanical, and Industrial Materials.** AMETEK employs about 6,700 people at 30 plants in the United States.

Since mid-1979, AMETEK's power systems group has produced and marketed hot water solar collector panels from a new plant in Pennsylvania.

While it has not yet produced photovoltaic cells for the market, AMETEK entered the photovoltaic business in 1979 when it purchased Silicon Material, Inc., of Mountain View, California, a small company which produced silicon and photovoltaic cells. AMETEK has moved the photovoltaic operations of Silicon Material to Paoli, Pennsylvania, and operates the silicon production portion in Mountain View and Sunnyvale as an AMETEK corporate division.

In 1979, AMETEK filed patent applications on its entirely proprietary, company-funded development of a very low cost photovoltaic cell based on electrodeposition of a thin film semiconductor consisting of cadmium telluride and other materials. The basic patent covered the photovoltaic cell; a second patent application, describing methods for producing the cell, was subsequently filed. Both patents were issued in 1981. AMETEK expects to begin a pilot production program later in 1981.

Up to this point, AMETEK has accomplished this with its own funds. Until recently, it had neither requested nor received Government funds. Recently, AMETEK submitted an unsolicited proposal to DOE seeking to obtain a substantial amount of funding to help accelerate the rate at which it will be able to move into production of its new cell. This request is not for basic R&D funds, but is for engineering and application research. AMETEK stated that if it receives this assistance, it expects to be able to meet the 1986 DOE cost goal of producing PV cells for 70 cents per peak watt, but if it cannot get funding assistance it will not reach this point by 1986.

### Applied Solar Energy Corporation City of Industry, California

This company actually began business many years ago under the name of National Fabricators. Sometime after that it became known as Hoffman Electronics, and still later became the Central Laboratory Division of Globe Union Corporation. In 1974, it was purchased by Optical Coating Laboratory, Inc. and from September 1974 to October 1978 was known as the Photoelectronics Division of Optical Coating Laboratory, Inc. In October 1978, Optical Coating Laboratory changed the division's status from a corporate division to a separate subsidiary corporation, and from October 1978 to about December 1978 or January 1979, it went by the name of Photoelectronics Corporation of America. However, another company already had that name, so in January 1979 it

## APPENDIX I

changed its name to Applied Solar Energy Corporation. In July 1980, Applied Solar Energy Corporation issued public stock which diluted Optical Coating Lab's ownership to approximately 66 percent.

The company, through all of its various transformations, has been in the business of manufacturing PV cells and related equipment throughout its life. The very first PV cells in the United States were made by Bell Laboratories; the second batch was made by National Fabricators. National Fabricators was the first company to make PV cells for the U.S. space program.

Applied Solar Energy Corporation claims to be one of only two companies, the other being Spectrolab, Inc., which at the present time manufacture PV cells for U.S. space programs. It also manufactures cells and panels for the terrestrial market, both domestic and foreign. In 1980, its total sales, all PV related, were about \$9.2 million; 1981 is expected to hit about \$10 million. About 50 percent of its sales are to the U.S. Government.

The company recently announced a key strategy of expanding beyond its base business of photovoltaic components to include the assembly and sale of complete photovoltaic systems in selected markets. As part of this strategy, it purchased the business of Solar Electric Ltd. in February 1981. Solar Electric assembles and markets "Sun Pumps"--portable water pumping systems powered entirely by PV cells. Applied Solar Energy sees the primary market for these pumping systems to be the agriculture sector of developing countries.

### ARCO Solar Industries Los Angeles, California

Atlantic Richfield Company (ARCO) got into the photovoltaics business several years ago by purchasing a small PV company called Solar Technology International, which had been founded in 1975 by a former president of Spectrolab, Inc. At the time that ARCO purchased the company, it had only eight employees. ARCO renamed the company ARCO Solar, Inc. ARCO Solar is now one of the largest producers of PV cells in the world. In the ARCO hierarchy of companies, ARCO Solar, Inc., is subsidiary to ARCO Solar Industries (formerly ARCO Ventures Company) which is subsidiary to the Atlantic Richfield Company--the parent or grandparent company.

After ARCO acquired ARCO Solar, it installed a modern, automated assembly line to produce the silicon wafer cells that Solar Technology had been making by hand labor. By its own description, ARCO Solar has one of the best, if not the best, facilities for manufacturing PV silicon wafer cells in the country--maybe in the world.

## APPENDIX I

Dr. Karl W. Böer  
Member of the Board of Directors,  
American Section,  
International Solar Energy Society  
Newark, Delaware

Dr. Karl W. Böer is a professor of physics and engineering at the University of Delaware and editor of several professional journals. He holds two doctorate degrees from Humboldt University in Berlin and was engaged in solar energy-related research even before moving to the United States in 1961. Much of his time at the University of Delaware has been spent on solar cell research and development. He has been a member of the International Solar Energy Society (ISES) for 12 years, and is now a member of the Board of Directors of the ISES American Section and Director of its Physics Division. He also serves as Chairman of the Publications Committee of ISES and is Director of the Mid-Atlantic Solar Energy Association. He was chairman of the American Section of ISES from 1976 through 1977.

Dr. Böer founded Solar Energy Systems, Inc., (now known as SES, Inc. --see p. 13) in 1973 to develop and manufacture cadmium sulfide/copper sulfide photovoltaic cells. It is now an 80-percent-owned subsidiary of Shell Oil Company. Dr. Böer still serves as the SES chief scientist. Dr. Böer has published his research in 250 technical papers and holds 29 patents relating to the interaction of solar energy with matter. He built the Solar One solar residence in Delaware and now lives in a home of similar design.

Crystal Systems, Inc.  
Salem, Massachusetts

Crystal Systems, producer of the world's largest diameter sapphire, has adapted its unique Heat Exchanger Method (HEM) for growing square-shaped silicon ingots for solar cell production. It has also developed a new slicing technique to produce more wafers per inch than previous methods. The company claims that its HEM process will produce silicon ingots of high quality for very low cost. The square shape reduces material waste in cell fabrication and increases efficiency of the finished panels through more dense cell packing ratios. It claims that the high crystallinity of its HEM ingots is the best produced by any casting process and that solar cells fabricated from HEM silicon yield conversion efficiencies of around 15 percent.

These processes have been developed under funding by the National Aeronautics and Space Administration's (NASA) Jet

## APPENDIX I

Propulsion Laboratory (JPL). <sup>1/</sup> Since 1975, Crystal Systems has received \$2.5 million in Government funds. The company is presently building a prototype production facility and will go on to build 10 furnaces. To build these 10 HEM furnaces, the company is seeking private capital. The president of the company said that it could never have raised the funds to develop these two processes without Government support. It is now seeking private capital to move into the production phase.

Crystal Systems is also studying the possibility of using different grades, or levels of purity, of silicon for photovoltaic cell production. Semiconductor-grade silicon reportedly costs about \$65 per kilogram.

### DSET Laboratories, Inc. Phoenix, Arizona

DSET Laboratories, Inc., is a small business currently employing 65 persons. It does not manufacture or sell any products. Its only business is performing and providing materials and product testing services and laboratory analysis. The major part of its business is performing sunshine and weather exposure tests of materials and devices for other companies and Government agencies. DSET has about 600 different clients, or customers, in a given year. About 150 to 160 of these are from outside the United States. While its U.S. customers range in size from the largest corporations down to the smallest companies, its foreign customers are usually the giants in their industries and countries--the international Fortune 500 types.

DSET's list of services includes accelerated and conventional weathering, optical and radiometric measurements, calibration, durability/reliability and thermal performance testing of solar collectors, durability/reliability and performance testing of photovoltaic cells and modules.

### Energy Materials Corporation Harvard, Massachusetts

Energy Materials Corporation (EMC) is not in the business of producing and marketing photovoltaic cells. It is developing a method of producing silicon in a thin film ribbon format. Once its technology is perfected, it intends to produce thin film ribbon silicon for sale to companies that will then produce photovoltaic cells.

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<sup>1/</sup>Within DOE's Photovoltaics Program, SERI is Lead Center for Photovoltaics Advanced Research and Development and JPL is Lead Center for Photovoltaics Technology Development and Applications under an agreement between DOE and NASA.

## APPENDIX I

EMC's basic technology involves developing a machine which can produce three silicon ribbons at once. It also pulls the silicon ribbons horizontally instead of vertically, as do most other ribbon processes. EMC claims that its process allows ribbon growth at about 50 centimeters a minute compared with other processes which grow at about 2 to 3 centimeters per minute.

EMC claims that just one of its machines will be able to produce enough silicon ribbon in a year for all of the photovoltaic cells produced last year. It feels that it has a genuine technology breakthrough and it is just a matter of getting it to the production phase.

EMC believes that its technology will permit photovoltaic producers to beat the DOE cost goal of 70 cents per peak watt by 1986.

EMC plans to try to move into production sometime next year. It plans to license its machines to large companies and produce ribbon silicon itself for sale to small companies. EMC has already been approached by Siemens AG and Wacker-Chemitronic Gesellschaft fur Elektronik-Grundstoffe MBH (Wacker), German companies; Compagnie Generale d'Electricite (CGE), a French company; and by Japanese representatives.

### Exxon Enterprises New York, New York

Exxon Enterprises, a division of Exxon Corporation, is the immediate parent company of Solar Power Corporation. In addition to Solar Power's production and marketing activities, Exxon is also conducting R&D in two areas of solar energy: (1) high temperature solar thermal work involving concentrator systems and a DOE funded project to study the use of solar thermal processes to generate steam for use in enhanced oil recovery and (2) fully corporate-funded R&D on reducing photovoltaic cell production costs. It is also studying ways of lowering the cost of photovoltaic-grade silicon. In this effort, it has recently joined forces with Elkem A/S, a Norwegian silicon producer, in a jointly sponsored R&D program to reduce silicon production costs.

Solar Power Corporation, headquartered in Woburn, Massachusetts, manufactures and markets single crystal silicon photovoltaic cells, panels, modules, generators, power conditioning equipment, and module arraying materials. It also designs and occasionally installs complete photovoltaic power systems. Exxon officials stated that Solar Power Corporation was created about 9 years ago to serve the commercial photovoltaic market. The company did bid, however, on four major DOE demonstration projects, and won three of them--the New Mexico State University, Beverly High School (Boston), and Lovington, New Mexico, shopping center demon-

## APPENDIX I

stration projects. In addition to the DOE demonstration projects, Solar Power has also participated in three block cell purchases by JPL.

Solar Power officials stated that about 70 percent of the company's sales are for export. They have sold to about 65 different countries. At present, the company has agents and distributors in 35 countries.

### Ford, Bacon & Davis Utah, Inc. Salt Lake City, Utah

Ford, Bacon & Davis is a large engineering construction company that claims to have had at least one power project under way every single day since it first went into business in 1894. The company does a great deal of business in the coal, oil, gas, and nuclear industries, and a modest amount of photovoltaic work. It has contracted with both the Federal Government and the private sector; most of its work is probably in the private sector. The company is not a manufacturer of photovoltaic equipment. It designs, engineers and constructs photovoltaic systems using cells and panels manufactured by other companies.

Ford, Bacon & Davis has about 200 employees in Salt Lake City, about 600 in Dallas, Texas, and a much larger contingent in Monroe, Louisiana. It considers Monroe to be its corporate headquarters, although its president is located in New York City. About 2 years ago, the company was purchased by Deutsche Babcock AG, a German company.

### Free Energy Systems, Inc. Holmes, Pennsylvania

This is a small company employing about 30 persons. Its principal business is manufacturing and marketing small photovoltaic panels and modules for marine applications (providing electrical power for radios and navigation lights on boats and barges). It does not make its own PV cells; it buys them from other companies.

Its marine PV panels sell for about \$30 per peak watt, and the company reports that they are selling very well. The company projects 1981 gross income to be about 10 times larger than it was in 1980. It has a contract with the Navy to provide PV power systems for navigational lights on sea-going barges.

### General Electric Company Space Division, Solar Section Philadelphia, Pennsylvania

GE does not manufacture photovoltaic cells or systems. It does assemble and install integrated photovoltaic systems for Government-sponsored programs or other customers using cells

## APPENDIX I

purchased from other companies. To date, most of its sales have been to the Government.

GE is considering producing photovoltaic cells for the market, but at the moment is merely running a small R&D program with Government funding. During the past year, GE displayed photovoltaic shingles developed as an experiment.

Dr. Peter E. Glaser  
Vice President, Arthur D. Little, Inc.  
President, SUNSAT Energy Council  
Editor, Solar Energy  
Cambridge, Massachusetts

Dr. Glaser has been involved in solar energy work since 1950 when he joined Arthur D. Little. About 70 percent of Arthur D. Little's work consists of private consulting and contract R&D. It has also been doing considerable R&D work for SERI on wind energy, solar thermal, and photovoltaics. It was one of the contractors involved in DOE's country energy assessments. Dr. Glaser is president of the SUNSAT Energy Council and Editor of the journal, "Solar Energy."

John V. Goldsmith  
Vice President, Solarex Corporation  
Rockville, Maryland

Mr. Goldsmith is Vice President of Solarex Corporation, which is reportedly the largest manufacturer of photovoltaic cells, panels, and modules and has a large share of the world PV market. Solarex produces both single crystal and polycrystalline silicon cells but is concentrating future automated production on the polycrystalline silicon.

Solarex apparently developed its foreign markets through a network of joint ventures and other affiliations with a number of European companies with access to European and African markets. According to the Solar Energy Intelligence Report (SEIR), Solarex is working at developing a similar U.S.-European network to manufacture its products. In the late 1970s, Solarex sold three 14.5-percent equity shares to (1) a group of Italian investors, (2) Standard Oil Company of Indiana (AMOCO), and (3) Holec N.V. of the Netherlands. AMOCO's share is now 21 percent. Under one of Solarex's manufacturing facility agreements, the Italian group's equity share in Solarex was to be taken over by ENI, the Italian national energy company, which would help finance an expanded production plant in Italy where Solarex's polycrystalline silicon material and PV cells would be produced under license by Solaris, S.P.A. Licensed production of Solarex products also is, or will be, done in the Netherlands by HolecSol, in France by France Photon, and in Switzerland by Photonetics, Inc. Solarex is currently producing its polysilicon feedstock at a plant in Rockville, Maryland, operated by a subsidiary company, Semix, Inc., and a plant in Europe operated by Solaris S.P.A., a joint

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venture formed by Solarex (30 percent) and Montedison S.A. (70 percent) of Italy. Montedison's share has been taken over by ENI.

International Rectifier Corporation  
Semiconductor Division  
El Segundo, California

International Rectifier Corporation (IR) started in the semiconductor business in 1945. It was one of the pioneering companies in photovoltaics at that time. It made the first PV cells at that time from selenium; later cells were made from germanium. With the advent of the availability of semiconductor grade silicon, it switched its PV cell production to silicon.

IR was a pioneer in making PV cells and panels for NASA and Department of Defense satellites and the U.S. space program. It also sold PV cells and panels to aerospace companies producing satellites for the Government. At that time, only three companies were in the business. The other two have since dropped out.

Quite some time back, IR dropped all of its space work and Government contract work. Its PV production basically stopped at that time also, except for small specialized terrestrial systems in small quantities. About 2 or 3 years ago, IR decided to again seek a modest amount of Government contract PV work. As of now, its only Government contract is a small R&D contract for DOE's Sandia Laboratories.

Most of IR's work is in producing power equipment--concentrators, rectifiers, power conditioning equipment, etc. The same silicon technology applies to these products and semiconductor work as to PV work but uses larger items and equipment and larger pieces of silicon.

IR produces PV cells commercially as part of the power equipment it produces (mostly "detectors"). It also has some purely private sales of cells used in photovoltaic-powered electric fence chargers. It has financed all of its own product development. Because of this, it competes only in specialized small-panel business, such as the electric fence chargers.

IR's total corporate revenue in 1980 amounted to about \$150 million. Of that amount, only a small percentage represented PV-related equipment. The company's foreign direct sales of PV-related items used to amount to 20 percent of its total PV sales but is now only about 7 or 8 percent of total PV sales. It expects PV sales of about \$2.1 million for 1981.

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Lockheed Missiles and Space Company  
Palo Alto Research Laboratory  
Palo Alto, California

Lockheed does not manufacture PV cells. It produces PV panels and arrays only for its various satellites and space-craft produced under Government contracts for the Department of Defense (DOD) and NASA. Other than that, its only involvement in photovoltaics is in Government-funded research and development. At the time of our visit, Lockheed was working in two DOE-funded R&D programs. One was for R&D of cadmium sulfide/copper sulfide thin film PV cells; the other was for R&D of amorphous silicon thin film PV cells. DOE had informed Lockheed that due to the budget cuts, both of these programs would be discontinued upon expiration of the contracts in July 1981.

Martin Marietta Aerospace Corporation  
Denver, Colorado

Martin Marietta is a diversified industrial products company that now produces and markets such diverse products as cement, aggregates, chemicals, aluminum, and aerospace products. Its primary solar energy activities have been to develop heliostats for solar thermal electric systems and R&D in photovoltaic concentrator array technologies. Its solar energy work is concentrated on the needs of communities, cities, state governments, and utility companies and has been funded largely by R&D grants from the National Science Foundation, the Energy Research and Development Administration (ERDA), and DOE.

As of March 31, 1981, Martin Marietta had produced 1,818 heliostats (sun-tracking, concentrator mirrors) for the DOE's solar thermal power system demonstration project at Barstow, California, and 94 heliostats for the International Energy Agency's Small Solar Power Systems demonstration project in Spain. It expects that its total heliostat production will be 22,000 by September 1981. The company has about 110 persons working on its solar energy projects; about 82 on solar thermal electric and about 28 on photovoltaic concentrator array R&D.

Microwave Associates, Inc.  
Burlington, Massachusetts

Microwave Associates, Inc., a subsidiary of MACOM Corporation, claims to be the largest microwave semiconductor business in the United States. Microwave Associates got started in photovoltaics work about 3 years ago through a contract to assist the Massachusetts Institute of Technology (MIT) in developing high performance concentrator photovoltaic cells. When the MIT funding ran out, Microwave Associates hired the MIT engineers and continued the work on its own. The objective of the project was to develop a high-efficiency concentrator cell which Microwave Associates felt would be a natural outgrowth of its

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semiconductor business. The company then took its ideas to DOE and obtained DOE funding on two projects. Since then, Microwave Associates has had 2 or 3 contracts of about \$200,000 each with SERI and Sandia Laboratories. The company's total photovoltaics R&D budget over the last 3 years, or since it started the work, has been between \$500,000 and \$600,000--about \$400,000 in Government funds and over \$100,000 in company funds.

Microwave Associates is essentially still in the R&D phase. It is batch-producing some cells, but just for the learning experience--not for sale. It is also considering developing a hybrid module to capture and use the thermal heat developed with a concentrator assembly.

### Mobil Tyco Solar Energy Corporation Waltham, Massachusetts

Mobil Tyco Solar Energy Corporation is a joint venture created in 1974 by Tyco Laboratories, Inc., (20 percent) and Mobil Corporation (80 percent). Its stated goal is to develop photovoltaic solar cells at costs competitive with conventional power. While it is still mostly in the production development phase, it is beginning to produce and market cells from its pilot production facilities. The cells are made from silicon in thin film ribbon form fabricated by an edge-defined, film-fed growth process (EPG), a patented method for growing silicon crystals developed by Tyco.

Mobil Tyco currently offers two versions of its basic PV module (the RA-40) produced from the two-inch wide ribbon. It is also developing prototype machines that can grow up to 10 four-inch wide ribbons simultaneously.

Mobil Tyco estimates that only about 5 percent of its total R&D budget came from Government funding; the rest was corporate funds. The 5 percent portion comes from a contract with JPL to develop the multiple ribbon machine. It has done some R&D work for SERI in amorphous silicon, but that contract is completed.

Mobil Tyco constructed a desalination demonstration project in Saudi Arabia (funded by Mobil Corporation) that is independent of the SOLARIS project being run by SERI. The project was inaugurated in mid-1981. It is also bidding on other demonstration projects, including a United Nations desalination project in the Philippines. It also has a contract to provide photovoltaic modules for an Australian power plant.

Mobil and Tyco each also own 20 percent of the Japan Solar Energy Company. The other 60 percent is Japanese-owned. Mobil Tyco has sold Japan Solar its technology on a royalty basis.

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Motorola, Inc.  
Semiconductor Group  
Phoenix, Arizona

Motorola has been in the solar energy business for 5 years. For the last 4 years, it has restricted itself to photovoltaics R&D, production, and marketing. The only PV technology it has worked with is silicon. It is producing single crystal silicon cells in the conventional manner by slicing wafers from ingots it produces. At present, its PV cell production rate is very low. Its production line is largely manual. Motorola does not want to invest in automated production until it is sure that it has a stable, long-term technology. It is making a major effort in developing a new cell based on silicon thin-film ribbon. Motorola employs about 60 to 70 people in its PV operations. About 70 percent of its PV products are exported.

Photowatt International, Inc.  
Phoenix, Arizona

Photowatt International, Inc., a U.S.-based company and a French counterpart, Photowatt International S.A., were created in mid-1979 when the Compagnie Generale d'Electricite (CGE) of France and a U.S. company, Dyneer Electronics (which is partially owned by UTC International AG of Switzerland), purchased the photovoltaics operations of Sensor Technology, Inc., a Dyneer subsidiary. CGE and Dyneer each owned 50 percent of the new company. The Dyneer share has since been purchased by SAFT Corporation of America, a battery company. SAFT (Ste'des Accumulateurs Fixes et de Traction), however, is also a subsidiary of CGE, which means that Photowatt International, Inc., is controlled, if not owned completely, by CGE of France.

Photowatt International, Inc. (the U.S. company) markets primarily in the United States, South America, and the Far East and has some sales in Europe and South Africa. Photowatt International, S.A. (the French company) primarily serves the European market. A new company and manufacturing plant has recently been established under the name of Photowatt Afrique, located in Abidjan, Ivory Coast, to serve the African market. Each company manufactures and markets PV cells and modules. The U.S. company also engages in DOE-funded R&D work. The French-based company also performs R&D work.

The company that spawned Photowatt International, Inc., Sensor Technology, still exists and is still doing business at its headquarters in Chatsworth, California, but it is no longer in the PV business, having sold that to Photowatt.

Photowatt's plant in Arizona produces silicon wafers, silicon wafer PV cells, modules, and arrays. The general manager refused to disclose information on sales volume or profits. He did say that the U.S. plant exports about 35 percent of its production, mostly to South America.

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### SES, Inc. Newark, Delaware

SES, Inc., is an 80 percent-owned subsidiary of the Shell Oil Company, but, according to its president, it enjoys considerable independence in its decision making.

SES is the only company of those we interviewed that is developing solar cells of cadmium sulfide/copper sulfide thin film. It has only recently begun production for commercial markets at a very low rate. It is still mostly in the advanced stages of product development. Its current production is aimed at remote application markets. Its next goal is to expand these markets to consumer needs in order to support mass production to achieve its ultimate objective of providing PV systems for residential and industrial use at a price competitive with other energy sources.

SES has a policy of not using Government funding in product development. The company's immediate major objective is to reduce the price per peak watt to \$1.00 or less and to enter the commercial market with mass production in the mid-1980s.

### SILTEC Corporation Menlo Park, California

SILTEC Corporation consists of three product groups serving the semiconductor industry. Its products include silicon material (both wafers and ingots), ceramic packages and equipment for fabricating and processing silicon wafers, and automatic testing equipment. The company was also performing contractual R&D work relating to PV cells for the U.S. Government, primarily JPL. Its corporate headquarters are located in Menlo Park, with manufacturing facilities in Redwood City, Mountain View, and San Diego, California, and a new silicon production plant under construction in Salem, Oregon. Instrument products are manufactured in a separate plant in Menlo Park.

In 1980, the company had total sales of \$57,120,000, a 31 percent increase from the prior year. Its net income increased 33 percent to \$3,420,000. The company notes that during 1980 many new customers emerged from the third world countries. It has received or is negotiating major orders from Finland, Romania, and China, among others, for equipment with which to produce silicon substrates.

Up to now, all of SILTEC's PV work has been Government-funded R&D. In 1980, it spent about \$540,000 on PV R&D-- all Government funded. By comparison, it spent \$1.7 million on commercial, non-PV-related R&D in 1980. Only 1 percent of its total business in 1980 was from Government R&D work.

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### Spectrolab, Inc. Sylmar, California

Spectrolab, a subsidiary of Hughes Aircraft Company, has been in the photovoltaic business for about 20 years. The company was formed in 1961 to manufacture PV cells for the U.S. space program. It began developing foreign and domestic terrestrial PV markets (as opposed to space markets) in 1972 and at the same time began an R&D program to reduce cell cost. Spectrolab did contract work for both ERDA and the National Science Foundation in its early days and also built up a commercial business.

Spectrolab no longer produces PV cells or systems for the commercial terrestrial market, but concentrates on Government funded R&D and the space market. Most of its terrestrial R&D funds come from DOE. It has some private R&D funds for space projects, and the rest is from DOD and NASA. In addition, it has done some technology transfer work under contract to Australian, French, and other U.S. companies.

### Spire Corporation Bedford, Massachusetts

Spire Corporation, founded in 1969, is a high-technology company engaged in research, engineering, and manufacturing of photovoltaic cells and processing equipment for high-volume production of solar cells and arrays. The company began in other areas of research and development and got involved in photovoltaics work in 1975. Its corporate plan is to develop and market PV cell-manufacturing processes and equipment rather than to produce cells itself.

The company is producing cells now for the JPL block purchase program, but the purpose is primarily to test its production equipment. Spire believes that the DOE cost goals can be met. It believes that flat plate systems will form the bulk of the terrestrial market and that concentrator collectors will fill specialty markets--perhaps in the space market.

In addition to its work in developing manufacturing processes and equipment for conventional cells, Spire is also developing thin film processes for low-cost substrate fabrication, thin-film deposition (including amorphous silicon), and cell structure formation.

### Solectro-Thermo, Inc. Dracut, Massachusetts

Solectro-Thermo, Inc., (STI) was founded in 1976. It manufactures and markets hybrid photovoltaic/thermal collector modules which incorporate a number of features found separately in other companies' products. It uses round photovoltaic cells, purchased from a cell manufacturer, mounted under circular, highly-polished

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aluminum cones which both concentrate the sun's rays into the cells and absorb heat. The modules are covered with acrylic glazing to prevent heat loss. The heated air is drawn off the cells and used to heat water and/or air for water or space heating. The modules also employ a tracking device to increase the amount of solar energy captured over the more common fixed-position collector.

STI claims that by utilizing both the electricity and heat produced by its modules, it achieves a total energy conversion efficiency of about 60 to 70 percent, compared with the 8 percent or less of a standard flat plate photovoltaic panel which produces electricity only. Using these figures, STI states that the installed cost of its system translates to \$1.85 per peak watt of energy produced.

STI is now apparently out of business. It has licensed its patent rights to Solar Technology, Inc., an Oregon company that makes and sells flat plate solar thermal collectors and which intends to market STI's hybrid collectors nation-wide.

### Solenergy Corporation Woburn, Massachusetts

Solenergy is a small business that was created in February 1978 to manufacture and sell photovoltaic cells and modules. It also provides consulting services on all aspects of the photovoltaic industry, including marketing, potential applications, specialized product design, and plant design. It sells its products worldwide to a variety of customers. It sells only single crystal silicon cells.

Its president, Robert Willis, became a marketing consultant to Exxon Enterprises in 1972 to study the worldwide potential for using photovoltaic cells for remote power applications on earth (as opposed to space applications). This study led to the formation of Solar Power Corporation, which remained a small business until the middle of 1975, when it was absorbed into Exxon Enterprises as a wholly owned subsidiary. Mr. Willis was president and chief executive officer of Solar Power Corporation from 1974 to January 1978, when he left to form Solenergy Corporation.

Since its beginning in 1978, Solenergy has grown to an estimated \$1.5 million to \$2 million in sales for 1981, with about 60 percent of its sales going overseas. Solenergy has a total staff of 35 people. Although Solenergy was created with an eye toward the Government small-business set-aside program, less than 6 percent of its total sales have been to the Government.

In the past, the company has not done R&D work, but this year it has obtained a JPL contract to develop and produce cells for the commercial market using the HEM silicon process of Crystal Systems, Inc., and the ribbon silicon of Energy Materials Corporation. Solenergy's current production consists of single crystal

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silicon cells made from silicon wafers purchased on the open market; its usual supplier is Wacker of Germany.

### Sollos, Inc. Los Angeles, California

The president and founder of Sollos, Dr. Milo Macha, has been in the semiconductor and/or PV business for many years, working for large companies. In 1975, he left his last employment and formed Sollos to work on some ideas he had for new processes in producing single crystal PV cells. Sollos is a very small company. It has only five employees and makes nearly everything by hand. It produces and markets small silicon ceramic semiconductor articles and small special-use PV cells.

### Thermo Electron Corporation Waltham, Massachusetts

Thermo Electron Corporation is a diversified manufacturing and service company that produces process equipment, and monitoring instruments and provides manufacturing services for energy-intensive industries. Its customers include manufacturers of automobiles, oil and gas drilling tools, aircraft, food products, farm machinery, and weapons; producers of basic materials, such as paper, plastics, steel, and aluminum; and electric utilities, both fossil-fueled and nuclear.

Thermo Electron is currently in the R&D phase of developing a photovoltaic concentrator system that will produce both electricity and heat. Once the system is developed to the point of manufacture, the company hopes to license the process rather than actually produce photovoltaic systems itself. Its R&D program is being supported by DOE's Sandia Laboratory's concentrator program. The company feels that the concentrator will be better suited to reaching the 1986 cost goals than flat collectors that produce only electricity.

Thermo Electron estimates that it needs one more year in module design and another year to develop initial production capability. Lack of further Government funding will most likely terminate this project, as Thermo Electron will not invest further private funds without the prospect of an immediate domestic market.

### Varian Associates, Inc. Palo Alto, California

Varian Associates is a large electronics company that is very active in aerospace and semiconductor technology R&D and component production and photovoltaics R&D. Varian does not manufacture PV cells on a commercial basis. The only systems it has built and installed have been for Government demonstration programs. The bulk of its PV work, so far, is strictly in research, with more emphasis at the present time on research than on development. The PV laboratory employs 13 people, all engaged in PV cell R&D.

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Varian originally spent several million dollars of its own funds to get started in PV R&D. Most of its PV R&D program at the present time is funded by the Department of Energy, with an annual budget of about \$1 million to \$1.5 million.

Currently, Varian is working with concentrator modules using gallium arsenide cells.

Westinghouse Electric Corporation  
Power Systems Company  
Advanced Energy Systems Division  
Pittsburgh, Pennsylvania

The Advanced Energy Systems Division employs a staff of about 5,000. Its work is funded about 80 percent by Westinghouse and about 20 percent by Government R&D programs. The Division's basic purpose is to take promising technology out of the R&D technical laboratories and demonstrate hardware feasibility and advance the systems developed until the technology is ready for commercial production.

Its PV work at present is with a silicon dendritic web ribbon production process, a Westinghouse-patented process which was recently moved to the Division from R&D. This technology was developed entirely with corporate funds through the R&D phase. Since the initial results were promising, a decision was made to develop a pilot plant under the Advanced Energy Systems Division's responsibility to determine if cost reduction could be achieved with possible production in the future.

Westinghouse has obtained DOE funding for a large percentage of the pilot plant because it considers the engineering design phase as a high-risk area. Once the development process is completed and the production process is proven, Westinghouse will finance putting it into full production. Although Westinghouse had developed the dendritic web technique and holds patents on it, it felt that it could not afford to risk the capital investment necessary to develop the production methods in the event that cost reduction proved to be impossible.

Westinghouse plans to begin assembling the pilot manufacturing line in 1982, with completion scheduled for early 1983. It expects to be in full production with the pilot line by the end of 1983 at a cost of about \$5.00 per peak watt. As production methods improve, the company has high hopes of achieving a cost of 54 cents per peak watt by 1986. If this figure is achieved, Westinghouse sees the United States as its principal market.

SUMMARY OF COMPANY AND INDIVIDUALRESPONSES TO GAO QUESTIONS

Following is a summary of the industry responses to specific GAO questions. Not all companies answered or were able to respond to all questions. Some companies with little or no experience in the commercial photovoltaic market or in the foreign market indicated that they did not feel that they had sufficient experience or knowledge to comment.

1. If the current U.S. international solar energy programs (the DOE International Market Development Program and joint projects under international agreements) were to be eliminated, what would be the impact on the ability of the U.S. photovoltaics industry to compete in foreign markets?

- 1 - Question not applicable. (3 percent)
- 4 - No comment. (13 percent)
- 8 - Loss of these programs would have little or no effect. (27 percent)
- 5 - Loss of international agreements will not hurt; loss of Export Market Development Program will hurt. (17 percent)
- 12 - Loss of these programs would hurt the ability of the U.S. industry to compete in foreign markets. (40 percent)

2. If this change hurt the U.S. industry's competitive position in foreign markets, would this delay the widespread commercialization of photovoltaics in the U.S. domestic market?

- 4 - No comment. (13 percent)
- 9 - There would be no effect. (30 percent)
- 8 - There would be a slight delay. (27 percent)
- 9 - The effect would be to strongly hinder technological advancements, R&D efforts, commercialization, and cause slippage in reaching DOE's 1986 price goals. (30 percent)

3. Does the PV industry require continued support from the U.S. Government in order to successfully compete in foreign markets? If so, what should be the Government role?

- 4 - No comment. (13 percent)
- 2 - No, the industry does not need continued Government support. (7 percent)
- 22 - Yes, the industry does need continued Government support. (73 percent) The companies recommended a variety of activities; i.e., Government should support high-risk R&D, trade shows, international market development, educating the public, and export financing.

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2 - No; however the Government could educate the public and continue support for the international trade shows. (7 percent)

4. How does your company assess the size and nature of the foreign PV market?

1 - Question not applicable. (3 percent)  
3 - No comment. (10 percent)  
2 - Have not assessed the overseas PV market. (7 percent)  
24 - The market is between \$20 million and \$200 million in sales in LDCs, Europe, the Middle East, and Africa. (80 percent)

5. How has your company obtained or developed its foreign market?

3 - Question not applicable. (10 percent)  
3 - No comment. (10 percent)  
7 - We have no foreign market. (23 percent)  
17 - We have developed our foreign market in a number of ways. (57 percent)

6. Have you used the DOE International Market Development Program (solar export promotion)? the Department of Commerce Export Program? Have you found them helpful?

4 - Question not applicable. (13 percent)  
1 - No comment. (4 percent)  
4 - Used only DOE and found it helpful. (13 percent)  
6 - Have used both programs. (20 percent)  
4 - ...and found both helpful.  
1 - ...and liked DOE better.  
1 - ...had no results from either.  
15 - Have not used either program. (50 percent)

7. Which foreign companies and countries are your chief competitors?

3 - Question not applicable. (10 percent)  
4 - No comment. (13 percent)  
23 - Identified companies and/or the following countries as the major competitors: (77 percent)

France	- 17
Germany	- 20
Japan	- 12
United Kingdom	- 2
U.S. Government	- 1

8. How do U.S. photovoltaic products compare with foreign products in terms of cost, performance, and quality?

1 - No assessment made. (3 percent)  
4 - No comment. (14 percent)

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22 - U.S. products are superior, but some are unsure if this will last under the budget cuts. (73 percent)

2 - U.S. is technically ahead but lags in international marketing capabilities. (7 percent)

1 - There is no PV competition. (3 percent)

9. What assistance do foreign companies receive from their governments that U.S. companies do not receive?

11 - No comment. (37 percent)

19 - Foreign governments give the following types of assistance to their companies: (63 percent)  
--Free PV demonstration projects to LDCs.  
--Subsidies to companies for technology development.  
--Favorable financing.  
--Reduce internal competition.

10. What role do foreign governments play in developing markets for their companies?

13 - No comment. (43 percent)

17 - Foreign governments play an important role in developing markets for their companies, such as: (57 percent)  
--Fund PV demonstration projects in the target market.  
--Provide favorable export financing.  
--Provide timely information on potential foreign sales leads.  
--Solicit business through the government's embassies.

11. How do the capital needs of foreign companies compare with the capital needs of U.S. companies of similar size and activity? In other words, does the support of the foreign company's host government in developing markets, exporting products, or whatever it does, significantly reduce the capital needs of the foreign company?

13 - No comment. (43 percent)

10 - Foreign government financial support reduces the problem of access to capital for foreign companies. (33 percent)

7 - Their capital needs are no different. (24 percent)

12. Are foreign companies or governments developing their photo voltaic technology at a faster rate than is the United States?

6 - No comment. (20 percent)

6 - Yes, they are. (20 percent)

14 - No, they are not, but 5 of these companies said

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that the budget cuts could reverse this situation.  
(46 percent)

2 - Not sure. (7 percent)

2 - No, except for the Japanese. (7 percent)

13. How do U.S. marketing methods compare with those of foreign competitors?

13 - No comment. (43 percent)

11 - Foreign companies have a marketing advantage because they:

--Work closer with their governments to export technology.

--Are ahead in marketing methods.

--Receive favorable export financing.

--Have the freedom to adjust to local practices.

--Are not concerned with antitrust laws.

--Are more aggressive in market development. (37 percent)

3 - U.S. companies' international marketing methods lag behind because they:

--Are not as aggressive internationally.

--Are new to international marketing.

--Focus on small markets. (10 percent)

1 - U.S. companies are ahead in marketing because of better products. (3 percent)

2 - There is little difference in marketing methods. (7 percent)

14. Do U.S. companies face marketing barriers that foreign companies do not?

14 - No comment. (46 percent)

1 - Not aware of such barriers. (3 percent)

2 - No, they do not. (7 percent)

2 - There are no barriers. (7 percent)

11 - Yes, they face barriers such as difficulty penetrating EEC markets; insufficient knowledge of foreign markets; U.S. Government regulations; European colonial trading ties; local customs; dislike for the United States; institutional barriers such as language, culture, and taxes; financing disparities; and lack of international PV product standards. (37 percent)

15. How will the proposed budget cuts affect the U.S. PV industry's ability to compete in foreign markets?

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3 - No comment. (10 percent)  
8 - The cuts will have no effect. (27 percent)  
19 - The cuts will hurt the U.S. industry. (63 percent)

16. Will the withdrawal of the U.S. Government from demonstration and commercialization slow the development and commercialization of solar energy in this country? In the world?

4 - No comment. (13 percent)  
6 - No, it will not. (20 percent)  
20 - Yes, it will. (67 percent)

17. How serious is the problem of access to capital? Is risk capital available to PV companies?

5 - No comment. (17 percent)  
9 - Risk capital is available. (30 percent)  
16 - Obtaining risk capital is a problem. (53 percent)

18. If Government assistance is still needed, what form should that assistance take and why is it needed?

1 - No comment. (3 percent)  
7 - Government should support market development in areas such as:  
    --Finance for domestic and international sales.  
    --Tax credits.  
    --Demonstrations of PV systems, both domestically and internationally.  
    --Export promotion activities.  
    --Supporting smaller PV companies to offer stronger competition.  
    --Developing technology market pull.  
    --Determining the importance of PV market development. (24 percent)

16 - Government should support market development and research and development in areas such as:  
    --Funding long-term research, demonstrations and trade shows.  
    --Commercializing PV.  
    --Educating the public on PV systems.  
    --Stressing long-term research.  
    --Developing production technology.  
    --Continuing support for cost reductions.  
    (54 percent)

4 - Government should support research and development in areas such as:

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--Reducing the cost of PV raw materials.  
--Stressing research in PV fundamentals.  
--Funding high risk areas of PV and production methods. (13 percent)

1 - Government should provide SBA loans to small PV companies. (3 percent)  
1 - Government should take PV R&D from DOE and place it under NSF authority. (3 percent)

19. Will the PV industry ever reach the "take off" point where no Federal assistance is needed?

7 - No comment. (23 percent)  
22 - Yes. (74 percent)  
1 - Not sure. (3 percent)

20. Will the deregulation of oil and gas prices help the PV industry?

9 - No comment. (31 percent)  
18 - Yes. (60 percent)  
1 - Deregulation may not help over the long term. (3 percent)  
1 - Deregulation will not help over the short term. (3 percent)  
1 - Deregulation both helps and hurts the PV industry by (a) making PV more competitive and (b) increasing the price of other PV components. (3 percent)

21. Should the Government subsidize and assist any form of energy development and commercialization?

14 - No comment. (47 percent)  
16 - Yes. (53 percent)

22. Did your company plan its photovoltaic capital investment on the basis of the Federal Government's commitment to spend \$1.5 billion on photovoltaic development during the next 10 years?

4 - No comment. (14 percent)  
7 - Yes. (23 percent)  
16 - No. (53 percent)  
1 - Not sure. (3 percent)  
2 - Question not applicable. (7 percent)

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COMPANY AND INDIVIDUALS' STATEMENTS IN RESPONSE

TO GAO QUESTIONS

1. If the current U.S. international solar energy programs (the DOE International Market Development Program and joint projects under international agreements) were to be eliminated, what would be the impact on the ability of the U.S. photovoltaics industry to compete in foreign markets?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Since Acurex does not manufacture PV cells, the impact on our company would be minimal, but the impact on PV companies might be greater.

Anthony Adler

These budget cuts will not have any impact because the present commercialization efforts have not had any effect. The U.S. Government has not been supportive of exporting photovoltaics. As for joint agreements, the SOLERAS project will not further technology development. It should have purchased off-the-shelf technology rather than trying to push newly developed experimental devices. If the Saudi SOLERAS PV demonstration had used flat plate collectors (which are closer to being economically viable), it might have helped further U.S. markets, but there will be no benefit to demonstrating developmental concentrator collectors.

AMETEK, Inc.

We do not have enough information to respond. AMETEK is not in foreign sales.

ARCO Solar Industries

Eliminating these programs would have a positive effect, with one exception. The trade shows supporting U.S. exports sponsored by the Department of Commerce and those sponsored jointly with DOE have been helpful and effective. They should be continued.

Dr. Karl W. Böer

So far as the U.S. PV industry as a whole is concerned, the budget cuts and reduction of some programs have come at a very bad time. The industry needs a viable and substantive Government effort to bring down the cost and open up the market.

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There is a need for a secure U.S. Government market until the industry achieves a cost of \$3 to \$4 per peak watt.

If the budget cuts go through as planned, the U.S. PV industry could be set back 5 plus years in technological advancements and market penetration. This will place the Europeans and Japanese in a more favorable position to capture the international market and reduce U.S. companies' penetration in certain countries. Other countries may take advantage of the U.S. deemphasis of renewable energy, particularly PV. Germany is funding its PV industry heavily and providing incentives to export wherever possible.

The budget cuts have further important negative implications for the United States internationally than just the effect on the PV industry. The world community will perceive that the U.S. Government is sending the signal that it intends to shift away from renewable energy toward nuclear energy. Consequently, LDCs will turn in a similar shift toward nuclear energy to solve their energy problems. If this occurs, everyone will lose because solar energy offers by far a better solution for the world's energy problems.

Another important negative impact might be the ripple effect on deemphasizing PV research in universities causing a decline in the number of physics and engineering students. This will mean that the United States may face a shortage of trained scientists for future research and development in PV. Industry funding alone will not be able to continue the momentum of PV. It needs technological breakthrough and market development for the major gigawatt domestic and export market. If the Government and the industry pull out of aggressive PV development, the effect could be disastrous. It could set back the U.S. effort by 20 to 25 years.

If the budget cuts go through, the U.S. industry will lose its competitive position in foreign markets due to the sensitivity of the PV technology. The industry needs the continued support from the Government to successfully compete in foreign markets in order to shorten large delays that occur between material research and development of proven production methods. The high risk to introduce yet unproven production methods still can only be shortened by substantial Government assistance, as provided by other governments, notably Germany, France, and Japan. There is the potential for a multibillion dollar market in PV, but this market needs to be developed carefully. The Government is needed to bridge the price gap from today's price until the entry price of \$3 per peak watt is reached. It is needed to share the risk for early introduction of new processes and it needs to sponsor an overcritical research effort with clear signals of continuity.

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Frederick Schmid, President  
Cryst.1 Systems, Inc.

The DOE international commercialization program has been a good program and its loss will adversely affect U.S. PV companies.

DSET Laboratories, Inc.

The answer to this question involves two distinct responses-- one dealing with bilateral and other international agreements, and the other dealing with Federal support of international marketing.

(1) There are many problems with the way in which DOE goes about participating in international agreements. First, U.S. agencies can be naive concerning international cooperation and international conferences, and often give away U.S. technology which ends up in the hands of foreign companies which use it to compete against U.S. companies. The information flow at these conferences and in these agreements is entirely one way--from the United States to the European and Japanese participants, among others. Joint projects fail as a means of introducing U.S. solar companies to foreign markets. Secondly, the U.S. bidding system by which a U.S. company wins a DOE contract to implement a joint project invariably favors large corporations, not the many small companies that make up the real U.S. solar industry. Thirdly, the way in which the DOE and its subagencies select contractors to implement the joint projects usually works to the detriment of the U.S. solar energy industry. An example is the testing work under the SOLERAS Project which could have been handled in the private sector rather than in U.S. Government-owned national laboratories. Many of the projects themselves are OK projects, if they were managed in such a way as to involve more U.S. companies in each project -- especially those in the small business categories.

(2) The U.S. policy position for participation in international agencies, such as the International Energy Agency (IEA) type programs, should be formulated well in advance of the meeting or event, and should be formulated with the participation of private industry as well as Government. U.S. positions taken at such events should represent and protect U.S. private commercial interests as well as the U.S. Government. Furthermore, this U.S. position should be carried to these meetings and conferences by a team composed of both industry and Government representatives. The process that the DOE and the State Department use at present in matters of energy for formulating U.S. positions dealing with domestic and international commerce is weighted heavily toward representatives from Government agencies, and often from academia, both to formulate the U.S. position and to carry the position to the meeting. This effectively eliminates any input from U.S. industry and can leave U.S. commercial interests unprotected. On the other hand, the European governments invariably have a position considerate primarily of their commercial/industry needs.

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The U.S. position in these meetings is weak compared to the opposition. The U.S. performance in these meetings is often naive.

The DOE international commercialization program is a good program and should be continued insofar as it supports international marketing of U.S. technology (as opposed to giving it away). Eliminating the international marketing segment of the commercialization program would hurt the ability of the U.S. PV industry to compete in foreign markets, especially third world markets.

Exxon Enterprises

The impact on our ability to compete would be negligible. Developing a large market for American-made photovoltaic systems is dependent primarily on the ability of photovoltaics in general to compete with other energy alternatives.

Ford, Bacon & Davis Utah, Inc.

A cutback will hurt, but at this time we cannot tell how much. Development of new efforts to reduce technology costs will be slowed and competitive ability will decrease. We generally agree with the approach of developing PV for the foreign market first, but caution that PV is domestically commercially viable right now in certain applications. The extent of that viability is limited to remote stand-alone applications, and the technology is not fully developed. The reduction of Government stimulation spending may level off the cost curve decline or it may even rise again slightly as the private sector assumes more of the risk. In other words, the budget reduction will have the effect of stretching out the time frame in which PV will achieve full commercial viability on a widespread basis in the United States.

R. Douglas Wright, President  
Free Energy Systems, Inc.

The DOE export promotion program is beneficial and should be continued. Because solar energy companies lack sufficient capital, staff, and time to seek out and take advantage of overseas market possibilities, these exhibitions offer many opportunities that would otherwise fall to foreign competitors.

Free Energy Systems attended the DOE European Tour exhibitions and gained \$55,000 in sales and orders. Future and potential sales from the Tour contacts is even more promising. Since returning, we have installed a telex machine to communicate with our new European contacts. We estimate future sales from this series of shows between \$1 million and \$2 million.

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### Dr. Peter E. Glaser

The elimination of the DOE commercialization program and joint projects under international agreements would have only a limited effect on the ability of the U.S. photovoltaics industry to compete in foreign markets. The PV industry, which largely consists of firms associated with major companies, e.g., ARCO Solar, Solar Power Corporation, Photon Power, Solarex, Mobil Tyco, and Photowatt, is already competing in foreign markets through joint ventures. The DOE commercialization program has had only limited value because expectations that Government purchases could stimulate the photovoltaic industry were unrealistic. It is doubtful whether international demonstration projects, e.g., SOLERAS, the joint U.S.-Saudi Arabia project, will place the U.S. photovoltaic industry in a better competitive position in international markets due to the limited applicability of the technology, the cost of demonstration programs, and the political motivation for the programs. On the other hand, the PV industry could benefit from Government programs which would make it easier to compete in foreign markets through activities which stimulate the export of U.S. products, provide information on specific markets, and in collaboration with other Governmental agencies, e.g., the Agency for International Development (AID), assess energy needs and the applications for photovoltaics in various countries.

### John V. Goldsmith

I am not aware of very many joint photovoltaic programs under international agreements. The only such agreements that came to my attention at Solarex were with Italy and Saudi Arabia. However, if there were significant photovoltaic programs underway between the United States and other countries, Solarex and other companies would be aware of such efforts. So far, in our view, the U.S. Government has done little to assist industry to compete in foreign markets.

If the United States had an effective program like that of West Germany, its loss would hurt. For example, Germany, in cooperation with AEG Telefunken, is using the latest PV power system to provide electricity for a village in the South Pacific. Projects like this educate the people on the capabilities of the technology and give high visibility. The problem with PV today is that it is a technology looking for customers. Most of the world's people have never heard of PV and do not know what it can do.

The lack of capital and awareness in LDCs are major marketing barriers to overcome. The frugality of foreign government officials often results in purchasing inadequate systems. A way of reducing this problem would be to have PV demonstration projects by private industry with U.S. Government backing. This way, the experiences and knowledge obtained winds up in industry's

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hands and not in the Government laboratories. For example, the Upper Volta PV project under control of NASA's Lewis Research Center (NASA Lewis) could have been performed by industry.

### Lockheed Missiles and Space Company

Lockheed does not manufacture PV cells for the commercial market.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

Overseas marketing will be more difficult, but not impossible. The best way to commercialize is to let industry decide how they want to do it.

Motorola, Inc.  
Semiconductor Group

Eliminating these programs will slow the development and growth of the U.S. PV industry now and through the early growth stages--it will not have any long-term effect.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

The DOE international commercialization program is a good program, and it would hurt the U.S. industry to lose it. The international agreements program is nonproductive. It suffers from poor continuity and lack of dissemination of the resulting information to U.S. industry. The projects entered into under these agreements help the individual contractor who does the work, but the knowledge never gets beyond him--it never gets spread around to actually provide information to the U.S. industry as a whole. Demonstration projects of PV feasibility should be sited where they get maximum exposure to the industry and the public, rather than in remote locations where nobody ever sees them.

SES, Inc.

SES, as a matter of policy, has not taken Government funding for PV projects; consequently, SES will be unaffected by the reduction in the solar energy budget. We feel that we will be able to compete in foreign markets if we solve certain technical problems and go into full-scale production.

SILTEC, Inc.

Cutting the DOE commercialization program would be most detrimental to the U.S. PV industry. Technology development is

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changing so rapidly that any pause would cause the United States to fall behind foreign competition and risk losing a substantial market share.

### Spire Corporation

There might be a severe impact on U.S. ability to compete in foreign markets. Trade shows are a way of getting exposure overseas, lining up sales agents and customers. Being a small company with limited capital, we need Government assistance to break into foreign markets.

### Robert W. Willis, President Solenergy Corporation

There will be little or no effect. DOE's handling of joint projects has not been for the overall good of the U.S. industry anyway. For example, when the SOLERAS project was first announced, or discussed, it was thought that the whole industry would be able to participate. DOE was talking about using basic technology flat plate collectors and purchasing from a large number of different companies. This way everyone would get a share, and the demonstration project would show how these various systems performed in the actual market place. Instead, the final decision was to use an advanced technology concentrator system and use only one supplier, Martin Marietta. Another example is the Beverly High School Demonstration Project near Boston. This entire project went to Exxon's company, Solar Power Corporation. Solar Power does not have a capital problem, so why should it receive Government funding? There were then eight manufacturers of PV cells and systems in the industry; they should have all shared in these large projects.

The commercialization program has not consisted of much more than foreign aid. The State Department does little to help U.S. business, as opposed to the French Government which really supports its PV industry. For example, the French were providing educational television systems to the Ivory Coast as a foreign aid project. To provide electrical power for the TV systems in remote locations, they sold the Ivory Coast PV installations. By contrast, to get any business from U.S. AID projects, a company has to have someone sitting on AID's doorstep day and night and we cannot afford that. In addition, we think that the banking services the French provide their former colonies somehow tie these LDCs to buy French exports.

In short, loss of these Government activities will not affect the ability of Solenergy to compete in foreign markets because they never helped in the first place.

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Dr. Milo Macha, President  
Sollos, Inc.

The budget reduction would definitely reduce the ability of the U.S. PV industry to compete in foreign markets for all companies except those that have access to other sources of capital, most notably those owned by major oil companies or other large corporations.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

The foreign market is in the LDCs where our European competitors already have access because of past trading ties. To get access to these markets, U.S. companies must do things like Solarex is doing; i.e., setting up marketing agreements with foreign companies to take advantage of their market channels.

Varian Associates, Inc.

The industry's ability to compete in foreign markets will definitely be reduced. The FY 1982 U.S. PV budget will be smaller than the European Economic Community (EEC) PV budget. The French and the Germans are the main contributors to EEC's spending and our major competitors, notwithstanding the considerable investments and achievements accomplished in Japan. With a greater investment, the European PV industry will no doubt be moving more rapidly than that of the United States.

Westinghouse Electric Corporation

Westinghouse is not ready to participate in an international market and consequently has not been following the specific details of the U.S. international solar energy programs. If these programs were eliminated, we assume that it would put U.S. manufacturers in a less favorable position to compete in foreign markets, but we are not prepared to assess this in any quantifiable manner.

Other comments

--Cutting out the international projects obviously would eliminate a segment of business opportunity for U.S. companies. Secondly, eliminating these programs (and reducing the R&D budget) will reduce the U.S. competitive position in advanced technology. It will probably not impact much upon the basic silicon cell technology, but it will have the largest marketing effect upon the advanced technology where the United States has its greatest competitive edge over the French and Germans. It will leave the United States to compete only with lesser technology and will put

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the U.S. industry on a collision course with the foreign government-sponsored companies of Japan, France, and Germany.

--Reducing or eliminating these programs will not have much impact. The international market is very important, but the DOE program has not had much to do with developing that market so far. Cutting out the DOE program, therefore, will not have much immediate impact. It will only serve to eliminate whatever future benefit the program might have generated.

--Cutting back Government-funded demonstrations will slow development somewhat. Reduction of Government funds will not affect our company because of its backing by the parent corporation, but it probably will adversely affect the smaller independent companies.

--It has been difficult for the DOE to get individual companies to commit to a specific technology since the PV technology is changing so rapidly. Companies are reluctant to invest their own funds in a particular technology and find it suddenly made obsolete. We feel, therefore, that the budget reduction will hurt and slow down development in the industry, because the Government has been carrying the risk of making the investment commitment to develop different technologies. Without the Government shouldering this risk, development will be very slow in the private market.

--There will be a large impact due to the support and subsidization provided by foreign countries to enable their manufacturers to penetrate the PV market.

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2. If this change hurt the U.S. industry's competitive position in foreign markets, would this delay the widespread commercialization of photovoltaics in the U.S. domestic market?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Acurex's strategy is to concentrate on the U.S. domestic market first, since its major product is aimed more towards large industrial and utility centralized systems. PV cell manufacturers, on the other hand, have focused more on the foreign market for small systems. In this respect, the change in the U.S. solar energy budget may slow the sales by PV companies by reducing their competitive position in foreign markets. This would, in turn, delay their ability to develop a domestic market.

Anthony Adler

See response to question 15.

AMETEK, Inc.

Although AMETEK would hate to see the Government terminate some of the solar activities, the proposed budget cuts will not affect AMETEK's decision to pursue solar thermal and PV R&D efforts and commercial objectives in the private market. If the budget cuts are too deep, however, the industry's PV production may slip. If the budget cuts go too far into R&D, it will set back the rate of U.S. PV technological advancement. This will slow the rate of product entry into the commercial market in the United States.

ARCO Solar Industries

No, it would not delay commercialization of PV in the U.S. domestic market.

Dr. Karl W. Böer

If foreign markets are not penetrated profitably soon, development of the domestic market will be delayed. If the delay is sufficiently long, the major sponsoring industry will tire of funding losing operations and withdraw their investments, thus setting it back even further.

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Frederick Schmid, President  
Crystal Systems, Inc.

This will have an adverse effect, since the first markets will be foreign, where both experience and market share must be gained.

DSET Laboratories, Inc.

Yes, a delay of U.S. penetration of foreign markets would delay the development of a U.S. domestic market. The commercial foreign market is much larger than is the current domestic market.

Exxon Enterprises

Since we do not feel that the absence of an international solar program will seriously impact our competitive position in foreign markets, we do not see how this could affect the commercialization of photovoltaics in the domestic market. The domestic market will grow when photovoltaic technology advances result in lower costs that allow photovoltaics to compete with other energy sources.

Ford, Bacon & Davis Utah, Inc.

Yes, it will. Particularly by allowing foreign manufacturers to take over a significant fraction of, and perhaps even dominate, the U.S. market in areas of labor intensive jobs such as PV panel assembly. Commercialization of PV systems in the United States would then be done by foreign companies.

R. Douglas Wright, President  
Free Energy Systems, Inc.

We do not see a residential market for PV systems in the near future until after the year 2000 due to the current cost of between \$60,000 and \$150,000 for a complete self-sufficient system. Nevertheless, PV systems now have a domestic market in communications, marine usage, islands, and irrigation systems. As the price drops, market application will increase into many areas.

Dr. Peter E. Glaser

The PV industry requires expanding markets to justify investment in R&D, development of new products, and improved production equipment. Expanding foreign markets are essential to the growth of the U.S. PV industry because they will allow the reduction of manufacturing costs through mass production. Eventually, PV systems will be competitive in domestic applications, which primarily will be power grid connected. Commercialization of photovoltaics in the U.S. domestic market will be aided by Government support of R&D to develop lower cost solar cells and improve manufacturing

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methods, rather than by attempts to commercialize existing PV systems. The penetration of U.S. produced PV systems in international markets will depend not only on the specific PV technology but also on appropriate Government actions--for example, the availability of loans to potential purchasers.

The U.S. PV industry could also benefit from the potential market for PV systems for use in space for both commercial and defense applications such as space shuttle missions, space operation centers, and solar power satellites which conceivably could exceed the U.S. domestic market for PV systems in the 1990's.

### John V. Goldsmith

Presently, PV technical developments are moving along quite well, but at this stage price depends on volume of sales.

### Lockheed Missiles and Space Company

No comment.

### Wesley G. Mathei, Manager Solar Products Division Microwave Associates, Inc.

There will be only a slight negative effect.

### Motorola, Inc. Semiconductor Group

Yes!

### Robert W. McGinnis Vice President and General Manager Photowatt International, Inc.

Yes, it will hurt the ability to compete overseas and thereby will reduce the momentum to develop the domestic market. It will hurt and thin out the small U.S. companies.

### SES, Inc.

Companies that are sufficiently capitalized should be able to continue the momentum in commercializing PV without much delay.

### SILTEC, Inc.

Yes. Delay of technology development will postpone advances necessary to lower costs to competitive levels for the U.S. domestic market.

Spire Corporation

There may be some delay just because most of the PV industry sees the near-term market as being a foreign market. If they do not prosper in the foreign market, that could delay domestic marketing efforts.

Robert W. Willis, President  
Solenergy Corporation

There should be no effect, since the Government programs have been ineffective anyway. Commercialization of PV will take place, it will just take longer in the United States than in LDCs because we have a central grid electrical distribution system which provides electrical power at a much lower cost than the rest of the world.

Dr. Milo Macha, President  
Sollos, Inc.

Yes, it will. The U.S. terrestrial PV market was created and is supported by the Government. If the Government steps out now, this market will fold up.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

The cutback should not effect domestic commercialization.

Varian Associates, Inc.

No comment.

Westinghouse Electric Corporation

The commercialization of photovoltaics in the U.S. domestic market will be a function of the cost of energy provided by photovoltaics. Photovoltaics are selling at higher prices in foreign markets than domestic markets because the cost of energy is higher in those foreign countries than in the United States. To the end that production facilities can be designed to accommodate a foreign and domestic market and costs can be reduced through quantity manufacturing, the foreign market is of benefit. However, there are potential suppliers who expect to reach competitive prices without being fully committed in the foreign market.

Other comments

--The U.S. Government's original idea was to create "market pull" in foreign countries in order to stimulate the manufacturing base in the United States and reduce the cost of PV cells.

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This concept has not actually been implemented far enough yet for the cutback to have an immediate effect, but it will definitely have a marked effect on future U.S. sales opportunities. It will delay the reduction in cost, it will slow U.S. sales, and it will definitely slow growth in the domestic market. In our opinion, the U.S. PV industry will never get to commercialization by the private sector without the U.S. Government's "market pull" effect.

--There will be no immediate effect on the U.S. domestic market. The effect will probably be that of delaying future market growth and development.

--The domestic market is 3 to 5 years away. The cutback may slow development of this market to a minor extent.

--Yes! The breakeven prices are much higher in foreign applications. The application would provide an avenue for the U.S. manufacturers to come down the learning curve.

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3. Does the PV industry require continued support from the U.S. Government in order to successfully compete in foreign markets? If so, what should be the Government role?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

U.S. technology is at least one to two years ahead of foreign designs. The problem is in the different marketing approach. For example: Acurex tried selling a PV system to China, only to find that the Germans had already given a similar system to them. Germany and France direct the activities of their companies to a far greater extent than does the United States in order to reduce internal competition between the companies. These Governments also provide funds for grants and provide demonstration projects in foreign countries in order to stimulate foreign sales. The U.S. marketing system cannot compete well with this approach even though it has better technology to offer and at an earlier date. Some of the German projects have backfired--specifically the photovoltaic village project that the Germans have given to Mexico. This has not worked well and the Mexicans are a little bit soured on German work. As to what this means for the U.S. Government role, I am not sure what I would suggest. I believe that some help is needed and the help is needed in a marketing approach, but I am not sure of the exact approach.

Anthony Adler

The Government should provide affordable export financing and encourage foreign import credits from other governments.

AMETEK, Inc.

U.S. companies are at a competitive disadvantage when selling overseas against foreign competitors. For instance, we are negotiating a large sale for solar collectors. The potential purchaser is a domestic company and we are competing with a foreign company. The potential buyer knows about the high quality and performance as well as the reasonable price of AMETEK's collectors. In the initial bidding, AMETEK clearly had the best product and the lowest price, but an Israeli company then revised its bid price from \$300 to \$240. It appears that the Israeli company must be receiving government support to achieve that low a price. The potential buyer had not yet made a decision, but AMETEK may not get the award.

ARCO Solar Industries

Some continued Government support of long-range R&D would be useful. The most effective Government role is in support of long-range R&D. This would help develop a talent pool if carried out in research centers or universities. The development of a domestic market would also help our overseas efforts. It is much more effective to point to products that are being sold in this country when selling overseas. We think this could best be accomplished through an added 15 percent on the Commercial Tax Credit, bringing the total to 40 percent (10% Investment Tax Credit, 15% renewable energy credit plus an added 15%),--the same percentage that is available to the homeowner for solar. The credit, for only a limited time, 5 years, if also available to utilities would accomplish much more than any other marketing assistance or "commercialization" activity of the Government. This stimulation would also take the place of the development side of research and development. Therefore we think it could save Federal money as well.

Dr. Karl W. Böer

I see a need for a secure Government market until the industry can reduce prices below \$3 per peak watt. The industry also needs Government financial support in getting companies to share the risk of early involvement. For example, PV cells can be produced several ways. The company that commits itself to mass production of a certain technology first may lose its investment as the other technologies may prove to be more cost-effective. This cycle can only be broken if substantial market pressure justifies an entry with sufficient probability to recoup the investment before competitors are ready--or earlier, if Government shares the risk.

Frederick Schmid, President  
Crystal Systems, Inc.

The Government role should be to open and develop markets overseas. Some of the Government reports on foreign market potential have been helpful in doing this.

DSET Laboratories, Inc.

Yes, the industry does require effective support from the U.S. Government. The role of the Government should be as follows: (1) to continue to foster export promotion activities, such as the trade shows, export seminars, "how to do business in foreign countries" seminars, etc., (2) there should be Government support for rapid development of both domestic and international product standards for both PV and high temperature solar thermal electric systems and components, and (3) the Government should do a more effective job of transferring the technology to industry on results of projects done with public funds.

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Exxon Enterprises

No. Nonetheless, the U.S. Government could take several steps which would progress photovoltaics. The Government could assume a public education role. In addition, it could perform long-term basic research not being done by the private sector. The Government could sponsor trade shows, bring foreign technicians to the United States to tour PV facilities, make information on photovoltaics available at our foreign embassies, and fund selected demonstration projects.

Ford, Bacon & Davis Utah, Inc.

Yes, the industry does need continued support from the U.S. Government. The Government can supply "seed" money for PV demonstrations to build and develop the market. The Government should further supply funds for R&D to reduce cost and provide funds to demonstrate the use of PV and its reliability in order to develop LDC markets. The market should develop in progression for small, remote commercial scientific use in the United States, to the much larger market of rural and village use in LDCs, and then on to the still larger U.S. residential and industrial markets. The U.S. Government should finance trade shows abroad where U.S. PV systems suppliers and their engineering arms can exhibit their capabilities and be assured that seriously interested clientele will seek representation as well as delivery of such systems.

R. Douglas Wright, President  
Free Energy Systems, Inc.

The Government should support the small PV companies to make sure they stay in the market and offer stronger competition against the large companies. Not only is the competition important, but so is the labor force and jobs. Small businesses provide 60 percent of all employment and create 80 to 90 percent of all new jobs. Consequently, the Government should be letting contracts to small companies to test new PV technological advancements as well as to the larger companies. Most PV and other solar technology breakthroughs, new ideas and new concepts have come from small companies. Small companies are innovators; large companies are marketers.

Dr. Peter E. Glaser

The Government role in support of the U.S. PV industry efforts to penetrate foreign markets should, in addition to R&D support, include financial aid to potential purchasers, particularly in developing countries, assessments of the availability of renewable energy resources in a specific country, definition of

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the potential markets for photovoltaics, requirements for in-country manufacture of PV components or systems, and the assistance of U.S. consular staff in dealing with in-country government agencies.

John V. Goldsmith

(1) PV technology has established credibility that will not go away just because of reduced Government support. The industry has the ability to make money without the Government's involvement. However, without Government support, photovoltaics will not develop so rapidly.

If success of the industry is to be measured by immediate commercial success, the answer is "no." The industry has the ability to develop through natural market forces in due time. However, if success means rapid implementation of a significant alternative energy source, the Government has an important role to play and the answer is "yes."

(2) The Government should revitalize the National PV Program Plan of 1979. This was a good program with meaningful goals and scheduling.

Lockheed Missiles and Space Company

Lockheed is not involved in domestic or foreign marketing and cannot readily address this question.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

No, the industry does not still need Government support.

Motorola, Inc.  
Semiconductor Group

The U.S. Government should do the following:

- (1) Counter the unfair trade practices of foreign governments.
- (2) Create a pool of seed money to stimulate early sales for a period of several years.
- (3) Continue the foreign trade shows to stimulate and support exports. This will especially help the small firms.
- (4) Educate the public as to what is cost effective in PV today. Stop dwelling on the mass market of 10 years from now and go after the current market. If we do not

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go after the current market, there either will not be a mass market of the future or it will belong to the foreign companies.

(5) Get DOE off the idea that announcing a goal of a declining price curve will bring it to pass. DOE's projected price figures are not realistic. Most of the industry will not be able to even hit \$2.00 per peak watt by 1986, let alone 70 cents.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

No, continued support is not needed, but to compete successfully to a major degree, the industry will need the international trade show type program. It will also need the U.S. Government to fund demonstration projects.

SES, Inc.

SES agrees with the administration that DOE should support high risk R&D, but leave commercialization to the market place.

SILTEC, Inc.

Yes, the industry requires continued Government support. The Government should at least continue both Technology Development and Applications (TD&A) and Advanced Research & Development (AR&D). Also, loans to foreign purchasers through the Export-Import Bank for PV systems would help to compete in foreign markets.

Spire Corporation

Yes, the industry still needs Government support in foreign marketing. Many companies need assistance or guidance in actually getting started in exporting.

Robert W. Willis, President  
Solenergy Corporation

Small businesses still need Government help. Export development trade shows are a good program. The second way the Government can help is by having a good foreign economic assistance program, and assuring that U.S. businesses have the opportunity to provide any goods and services under the program. Thirdly, the Government should help stimulate a PV market in Egypt, Saudi Arabia and other Middle East countries.

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Dr. Milo Macho, President  
Sollos, Inc.

Yes, continued help is needed, but the Government funds should be spent much more carefully, and in a better organized fashion than in the past in order to produce desired results.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

If the U.S. Government wants its companies to sell in the foreign market, then yes, the industry will still need Government support. Thermo Electron, however, does not see the first major market as being the foreign market. We see as the first significant market segment the domestic commercial, institutional and apartment building market.

Varian Associates, Inc.

No comment.

Westinghouse Electric Corporation

The budget cuts may slow the momentum U.S. companies have and prevent them from reaching DOE's cost reduction goals by 1986. If this occurs, the foreign companies will have an opportunity to move ahead. The U.S. PV industry should have continued support by the Government in high risk areas of R&D and in engineering production design and development in order to stay ahead of foreign competition.

Other comments

--The industry is better prepared to commercialize the technology than is the Government. When the Government entered the scene with its commercialization efforts, it had some negative effects. For instance, our company had certain customers lined up ready to buy PV and then the Government publicized the DOE PV cost reduction goals that it had projected. The customers then decided not to buy at that time but to wait for the cost to come down. The Government's role should be to prepare an entree' into other countries or other markets, to help U.S. companies learn how to do business in foreign countries, to help U.S. companies gain advantage over their foreign competitors. The Government, however, should not go after and deal with specific potential customers, because this interferes with the marketing advantage one company has over another.

--Government involvement broadens the market somewhat, however, no large negative impact is anticipated. The effect on individual companies depends on the size of the company.

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--The Government should provide some level of demonstration of PV technology both domestically and overseas. Since the foreign competition is heavily subsidized, any U.S. demonstration exposure overseas will help U.S. companies develop and market their technology more rapidly.

--No, the industry does not need continued Government support, but without it the competition will be at a very low level. Technical advancement will be slowed without Government R&D funds.

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4. How does your company assess the size and nature of the foreign PV market?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Acurex has not made any studies of the foreign PV market, but feels that the potential is large. There is a question of capital availability to the buyer in LDCs. Generally speaking, those LDCs that need PV the most can afford it the least because of the large front-end investment required. Because of this, Acurex feels that the best immediate market is in oil-rich LDCs. We do not see much of a market in Europe except the Mediterranean area. The major foreign market at the present time is in the Middle East, some of the richer African LDCs, and the Pacific Island nations.

Anthony Adler

The present terrestrial market is \$25 to \$30 million at the wholesale level, and should grow to \$150 to \$200 million easy by 1986. Africa will be our major market. But, if the United States really wants to sell overseas, we must provide the financing. Financing the initial investment is the real problem for many LDCs. We should just provide the right kind of financing (low interest, long-term) and let the commercial market take care of itself.

The U.S. space market, currently being supplied by just Applied Solar Energy Corporation and Spectrolab, Inc., is a \$5 to \$6 million-a-year business which should grow to about \$20 million by 1985.

AMETEK, Inc.

Large domestic and foreign markets will develop once the cost per peak watt has been reduced to between \$5 and \$2.80. In stand-alone applications there would probably be a domestic market of \$25 million and a foreign market potential of over \$1 billion.

ARCO Solar Industries

No comment other than the foreign market is very large.

Dr. Karl W. Böer

The market is a multi-billion dollar market.

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### Frederick Schmid, President Crystal Systems, Inc.

The early markets are overseas for non-grid applications. In most cases, the markets must be bank financed. This will delay entry into these markets. The size depends on how bankable the situation and the availability of bank financing.

### DSET Laboratories, Inc.

The current foreign market is much larger than the current U.S. market. A foreign market exists in solar thermal and remote decentralized and small centralized PV applications. To be effectively penetrated, this market needs capital, and in many LDCs the supporting infrastructure is still lacking. In short, the LDC market is potentially very large, but quite small at present except in those areas where capital is available in the form of foreign exchange. Foreign economic assistance is greatly needed in many LDCs to effectively generate a market for alternative energy products and sources. We heard that around the middle of April Saudi Arabia loaned the World Bank \$10 billion to meet Third World energy needs.

### Exxon Enterprises

The foreign photovoltaic market is growing rapidly. In 1980, foreign sales were about 1 megawatt. We estimate that in 1981, the market will reach about 1 1/2 megawatts, or sales of \$25 million. We monitor the market by using our established network of representatives and distributors in 35 countries, reviewing worldwide periodicals for local market developments, conducting in-house data research, and using some of the Government reports and information. The recent study done by DHR, Inc. for NASA-Lewis on the Philippines was especially helpful.

### Ford, Bacon & Davis Utah, Inc.

Africa: about 200-300 megawatts in small and medium sized installations from 10-300 kilowatt. South America: 50-100 megawatt in small and medium sized installations from 10-300 kilowatt.

This is a very large market, primarily in LDCs. We have made no formal assessment of the market, however, cost of PV systems is still high. Reduction of this cost will bring the market into focus.

### R. Douglas Wright, President Free Energy Systems, Inc.

The PV industry, at the present time, will have its best success in the international markets. Our company believes that its best opportunities lie in Europe and Latin America.

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### Dr. Peter E. Glaser

The major foreign markets will be for PV systems for use in developing countries for rural electrification at the village level. The potential market for PV systems is very large, ranging from water pumping to refrigerated storage applications; and if centralized power generation for community and commercial uses is included, the PV market could reach the gigawatt range over the next 20 years. However, the foreign PV market which can be penetrated by the U.S. PV industry will depend on many factors: the availability of investment capital from international development banks; political circumstances; U.S. commercial relations with specific countries; the success of PV marketing efforts by other industrialized countries, e.g., England, France, Germany and Japan; and the economic incentive for use of PV systems in competition with engine generators or other solar energy conversion technologies. The penetration of foreign markets will also depend on the willingness of the U.S. PV industry to establish manufacturing operations in specific countries. There may be a benefit for the U.S. industry to produce PV components and systems in foreign countries as is already the case in the electronics industry.

### John V. Goldsmith

The foreign PV market is growing, and competition from Japan, Germany, and France is also growing.

### Lockheed Missiles and Space Company

Lockheed does not produce PV products for the commercial market, only in the course of Government-financed R&D. We have had contact, however, with foreign companies in the R&D phase and generally know what the foreign companies are doing. The Japanese are pushing in a big way in PV and the U.S. Government had better make up its mind if the United States is either going to be in PV or is going to stay out of it. If the United States does not sufficiently fund its R&D and market development, the Japanese will take over the market. The Japanese are preparing to enter the world PV market in a big way as early as 1982. The Japanese see a market in the United States as well as in the LDCs and are going after both of them. The European companies are going primarily after the LDC market now, but the Japanese are after both the LDC and the U.S. domestic market.

Phillips' (a Dutch company) PV modules currently cost about \$22 per peak watt, based on 1979 costs (compared with \$7 to \$10 per peak watt, based on 1979 costs, for U.S. companies). Phillips does not see this as a problem because they can market their modules since their name is widely known in the electronics field throughout the world, especially in LDCs. Phillips has done a number of demonstration projects which demonstrate to the LDCs

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that their cells and systems will last at least 10 to 15 years with minimum maintenance problems. Because of this, and the reputation of Phillips and the fact that, like other European companies, Phillips designs and offers complete systems, not just PV panels, the LDCs are willing to pay the \$22 price.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

We are not in the market and have no assessment.

Motorola, Inc.  
Semiconductor Group

The world market amounted to \$36 to \$39 million in sales in 1980. It should be about \$50 million in 1981. About 40 percent of this market is outside the United States. This foreign market portion will probably increase to about 70 percent by 1985.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

The major foreign market is in communications and in the industrial/communications/agriculture area. This is a real market at the present time. Most countries have adequate private capital and government funds to finance investments in these areas. Photowatt terms this a real market because (1) the need exists, (2) PV is economic there, and (3) the potential buyer has the money with which to pay. A market of great potential is that of providing basic living improvements to the rural sector of LDCs. This will have to be funded by government foreign assistance. This would lead to the "near-grid" market both domestic and international. While it is potentially large, it is not an immediate market because it is unfunded. Every LDC that needs village and rural power also has a police and military communication network which will definitely have first priority on that country's development funds. Thus, we view the communications market as an immediate market, and the village and rural market as a future market. The difference is the availability of funds for the buyer.

SES, Inc.

SES is currently focusing its product, if and when commercialized, for remote areas. According to a study by an independent research organization, these areas offer the largest near-term market because of the electrical needs for communications, villages, and agriculture.

SILTEC, Inc.

SILTEC relies on studies by SERI and JPL and personal communications with other U.S. manufacturers.

Spire Corporation

We produce equipment used to make PV cells. Our first five sales of our latest product were three to Brazil, one to India, and one to Belgium. Our immediate market is overseas. Most domestic PV companies have been doing their own R&D and have developed their own manufacturing processes. Most foreign companies have not been doing the basic R&D work and are not already committed to any certain process. Because of this and the fact that most foreign countries (LDCs) do not have central electrical grids and need PV, most panel and module assembly will be overseas. We believe this year's foreign market will be about \$20 million out of a total market of \$40 million. Next year's sales will be about \$100 million and probably \$1 billion by 1990.

Robert W. Willis, President  
Solenergy Corporation

There is a \$100 to \$200 million remote power market which still can be captured by the PV industry. The major problem is where the buyers will get the financing to convert from oil or whatever to solar. The up-front cost of a major PV system is a problem even for U.S. buyers and especially for LDC buyers. There is a communication repeater station on a mountaintop near Denver which is privately owned and powered by a diesel generator. Every Friday, a helicopter flies in diesel fuel for the generator at great expense. Everyone in the PV industry has probably talked with the operator of this station about switching to PV, but he can not get the money for the up-front investment. There is a similar repeater station in Zaire, powered by diesel generators. The diesel engines are always breaking down. Finding someone to repair them is very difficult. The station is frequently inoperative for long periods awaiting repairs to its power plant. Here again, the PV companies have been unable to make a sale because the operator can not get up the initial investment capital.

Nevertheless, there is a potentially very large market for remote power PV systems throughout the world.

Dr. Milo Macha, President  
Sollos, Inc.

Sollos has made no assessments of the foreign market.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Thermo Electron got started in solar commercialization through an AID project in Senegal. Although the actual production of the solar system occurred some time earlier, institutional problems held up installation. The hardware had even been delivered to the site. When the installation crew arrived they had to dig around through the brush to find the equipment which had been left for 2 years. Even though this was an AID project, we invested about \$600,000 of our own money into the project because we thought LDCs would be a good market and we wanted to get into it. However, we soon found that there is very little money available for the potential customer and these countries cannot afford solar systems. We were also exploring South American markets, but have dropped it because of high marketing expense relative to sales potential. In India, the government typically will not let you sell in the country unless you set up a local manufacturing plant. Based on these experiences, we do not think there is a significant real foreign PV market.

Varian Associates, Inc.

No comment.

Westinghouse Electric Corporation

Westinghouse has not performed any formal assessment of the foreign market since we are not in the production phase yet. If we are able to achieve our goal of producing PV modules for 54 cents per peak watt, Westinghouse sees the U.S. as its principal market. Nevertheless, the foreign market will also be evaluated at that time to identify favorable market areas and the best methods of reaching them.

Other comments

--For fiscal year 1980, the foreign PV market was about \$25 to \$30 million in pure PV, not counting related hardware and equipment. According to Strategies Unlimited (a private consultant) about 80 percent of the total world PV market (excluding R&D sales), as measured in PV panel sales, is outside the United States, and 70 percent of that market is supplied by U.S. companies.

--The foreign market is very important. It is a large percentage of the total PV business.

--We have only begun marketing and have little overseas experience yet. We see 11 million diesel generators around the world. In parts of India, gasoline sells for about \$5 per gallon;

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in many other countries at remote locations, it is close to \$2 to \$3. The economics of conventional energy vs PV is real close now in foreign areas, and with all those generators we see a very large market overseas. The money is available. All those diesel engines and generators were paid for somehow, and the fuel they burn is being paid for also.

--The foreign market is larger than that of the United States in the near term due to the fact that many foreign requirements have:

- no grid.
- to pay more for diesel fuel.
- a greater market growth rate.

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5. How has your company obtained or developed its foreign market?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Acurex has no foreign outlets and no affiliation with foreign companies, except one. We have attempted and made efforts to develop outlets in various places. We have participated in the IEA project in Spain, and in DOC and DOE trade shows. Contact from these activities has led to individuals from other countries contacting Acurex and we have followed up on these leads. Acurex has also asked AID for various leads on projects being proposed or developed. Acting on some of these leads, we sent teams to the foreign governments concerned and made our proposal to them. We made these kind of proposals to Iran, Egypt, Yugoslavia, Greece, China, Australia, the Philippines, and Italy. This approach did not work at all.

About a year ago, we adopted the strategy of granting a license to a foreign company to market Acurex engineering services and products. At the current time, we have a license holder only in Yugoslavia.

Anthony Adler

The question is not applicable.

AMETEK, Inc.

AMETEK has been producing and selling flat plate hot water solar thermal collector panels since 1979. Since then, our sales have been good and increasing all the time. Our market for these collectors remains domestic, including Hawaii. The domestic sales have been so strong that we are not aggressively pursuing the overseas markets, other than a discussion with a Korean company that may sell and produce AMETEK panels under a licensing arrangement.

Our PV technology is still in the engineering design phase. We hope to move into PV production within the next 12 to 18 months. We just received the patents in 1981; the basic patent covers the PV cell itself, a second patent describes methods for production. The cell is a very low cost PV cell, based on electrodeposition of a thin film semiconductor consisting of common nonsilicon materials. It is entirely proprietary, having been developed entirely with company funds. Cost is the primary advantage to AMETEK's discovery; material costs right now appear to be considerably less than the cost of silicon, the common PV material used today.

ARCO Solar Industries

ARCO Solar has established foreign marketing operations with foreign nationals. The foreign operation is then responsible for developing its own market within its geographic area. ARCO Solar manufactures all of its products in the United States and ships them to the foreign distributors and buyers.

Dr. Karl W. Bør

The question is not applicable.

Frederick Schmid, President  
Crystal Systems, Inc.

We have developed a very economical process for producing high quality silicon wafers. We produce cube shaped polycrystalline silicon ingots cast via a heat exchanger method (HEM) and slice these ingots into square wafers with a multiwire slicing machine. We have the silicon casting techniques perfected, but are still working on the slicing methods. By using a fixed abrasive wire for slicing, we can produce 48 wafers per inch compared to the usual 25 per inch using the conventional blade saw.

Current sales are about \$10,000 per month. We are limited now by production capacity. Some of the sales are to foreign markets. We are testing some Japanese material in the HEM process, and believe that the United States may be putting all its eggs in one basket by relying only on semiconductor grade silicon for PV use.

DSET Laboratories, Inc.

DSET developed its foreign market by personal contacts, direct sales, and the company's domestic reputation preceding it. Many non-U.S. customers came to us because of our domestic and international reputation.

Exxon Enterprises

In 1973, we began developing an international network of sales agents and distributors. Each agent and distributor is responsible for developing their own local market. All production is done in the United States by Solar Power Corporation and exported to the point of sale.

Ford, Bacon & Davis Utah, Inc.

We have not yet entered the foreign market, although we have made a few tentative moves toward it. We did bid on the SOLERAS project and lost. We have also put out some feelers through Deutsche Babcock, a German company, and we have registered with

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the World Bank to participate in foreign energy projects. Brochures describing company capability in the solar area have been printed in English and French. We have supplied technical information to French and German firms operating in Africa's Sahel zone.

R. Douglas Wright, President  
Free Energy Systems, Inc.

Our company buys PV cells and manufactures PV systems for marine use. We had no foreign business until early this year when we attended the DOE/DOC European Tour trade shows in four European cities and secured \$55,000 in immediate sales and a projected \$1 to \$2 million in future orders.

Dr. Peter E. Glaser

The question is not applicable.

John V. Goldsmith

Solarex is a small business. It developed its foreign markets through its own aggressiveness.

Lockheed Missile and Space Company

Lockheed is not in commercial PV production and has no foreign market.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

Through discussions with foreign marketing personnel, Microwave Associates could have had three contracts to sell overseas, but we have decided that we are not yet ready for foreign marketing.

Motorola, Inc.  
Semiconductor Group

Motorola already has a worldwide sales and distribution network for its long-established radio, communications and electronics business. We sell PV products largely through our existing semiconductor, electronics and communications distributors.

Robert W. McGinnis,  
Vice President and General Manager  
Photowatt International, Inc.

Being French-affiliated, Photowatt has a big lead over other U.S.-based companies. The foreign business was developed by

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(1) previous French presence in the country, (2) inquiries from prospective customers, and (3) identifying specific functions which could use PV and then contacting potential customers active in those functions. In other words, we isolated target areas of economic activity in which to concentrate sales efforts.

### SES, Inc.

SES is still mostly in the final stages of developing its product - solar panels and modules incorporating a square, thin-film cadmium sulfide PV cell. So far it has produced only a few cells for commercial sale, and nearly all of these sales have been domestic. It hopes to be able to enter the commercial market in large scale in the mid-1980's.

### SILTEC, Inc.

Several foreign firms have expressed interest in potential product lines as a result of presentations at scientific conferences, and we have sold several silicon crystal furnaces (pullers) to Brazil.

### Spire Corporation

Spire sells through agents it has established overseas. Some of these agents were obtained with the help of DOE. We have also attended domestic trade shows sponsored by the Institute of Electrical and Electronic Engineers. We are considering a proposal to build a manufacturing plant in India.

Since our product is equipment to produce PV cells, rather than the cells themselves, our best markets may be those countries that prove difficult for the PV producers to sell. Brazil, for example, apparently plans to meet its PV internal market entirely from domestic production, and was one of our first foreign customers. We also see Asia, Europe and South America as important marketing areas.

### Robert W. Willis, President Solenergy Corporation

I have developed the company's foreign markets through personal contacts when I travel in Europe and during my previous overseas work. I have many well-established foreign contacts. Solenergy sells both cells and modules in Europe through distributors and agents.

### Dr. Milo Macha, President Sollos, Inc.

Sollos has a fairly significant foreign business for a very small company. We sell PV cells to Sweden, Switzerland, and

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Israel along with semiconductor items. We have received inquiries from Spain, Brazil, and a couple of other countries. This market was developed by hiring a marketing company in Northern California by the name of Cadre Corporation.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

While we have sold solar thermal systems in the past, our major effort at present is developing a PV/thermal concentrator array using plastic Fresnel lenses. We are still about 2 years of development work away from entering the commercial market with this system. We are aiming at the domestic commercial, institutional, and apartment building market rather than the foreign market.

Our previous foreign work was obtained through AID contracts. As a result of this experience, we concluded there really is not a foreign LDC market because of the lack of buyer financing and capital.

Varian Associates, Inc.

Varian is not in the foreign market.

Westinghouse Electric Corporation

Westinghouse is not prepared to supply a product to a foreign market and has made no effort to develop a foreign business. Westinghouse is an international company with an infrastructure throughout the world. If photovoltaics becomes a product line for Westinghouse and if it is determined that it should be distributed worldwide, we will work through our established organizations.

Other comments

--We developed our own distributors who then developed the market in their specific countries. Our largest foreign markets are in Canada, Mexico, and Southeast Asia, including Australia. We tried to develop a market in South America and dropped it, although we do have a few distributors scattered here and there in Latin America. We also tried to develop a market in Europe, and got nowhere. We have not yet tried Africa. It took 2 years to develop our market in Mexico and 2 years in Australia. South America is a natural market for the United States, but the United States as a whole or as a government is not doing much about it. The U.S. Government should take fairly quick measures to stimulate U.S. trade with Latin America. It could be a huge, huge market with just minimal development effort, and if the U.S. Government does not do it, the Japanese and Germans will have it tied up.

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--We went directly to the potential customers and developed direct sales. We currently sell our products in Indonesia, Japan, India, the United Kingdom, France, Italy, Canada, and to NATO. In the past, we sold terrestrial PV applications in Iran, Saudi Arabia, Italy, Australia, India, and Mexico.

--Right now, we are mostly in the R&D phase and are just beginning to prepare to enter the commercial market. We have developed a thin-film silicon ribbon PV cell and are developing a multiple ribbon pulling machine for production use. Earlier work in multiple ribbon production was funded by JPL. We have also done some R&D for SERI in amorphous silicon.

In developing foreign market potential, we rely in part on the foreign offices of our parent corporation. We are gearing up to produce PV systems for desalination. To date, sales have been very minor and are to the parent company or related businesses and a few direct sales to universities. Current production is very limited.

--Our foreign sales consist mostly of direct sales of small products, such as small PV cells or semiconductor items--detectors, small wristwatch PV cells, and this sort of thing. We have been selling many of these products overseas for many years largely as an outgrowth of our involvement in the semiconductor business. We have two factories in Europe, but do not produce PV equipment there. We have foreign indirect sales in a sense--we sell a rechargeable PV battery pack for a back pack radio to a manufacturer of radios, which in turn sells it to many developing countries. In general, in developing both our domestic and foreign markets, we followed up on DOE activity leads and leads from our foreign semiconductor business.

--We recently signed an agreement with a Belgian company to gain access to the Upper Africa and Middle East countries. The relationship is new and overseas sales will be assessed on an opportunity by opportunity basis. We have not yet done anything to establish ourselves in foreign PV sales, but are looking into various approaches.

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6. Have you used the DOE International Market Development Program (Solar export promotion)? The Department of Commerce Export Promotion Program? Have you found them helpful?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Acurex has used both programs, and has generated many leads from both, but has no results in terms of increased sales or sales outlets yet.

Anthony Adler

The question is not applicable.

AMETEK, Inc.

AMETEK has not used either the DOE or DOC programs. Since the company has focused its sales efforts on the U.S. domestic market for solar thermal collectors, there appears to be limited value on participating in these programs. We have not yet begun production of PV collectors, but as the PV product nears production we will assess both domestic and international market potential and will consider trade shows as a means of reaching markets.

In the past, we have been selective in participating in U.S. energy shows because little sales result from them for us, mainly due to the fact that our sales are limited to distributors and installers. A lot of time and money is required to effectively participate in a trade show. Many larger companies active in the solar collector industry have spent a lot of time and money on these shows with little return. To participate in DOE's four country European tour would have cost AMETEK about \$25,000. So far, based on inside information, we do not think it would have been worth it. Furthermore, our business has increased 10 times over last year's sales without being involved in the Federal programs or Energy Trade Association exhibits. Until benefits are recognized, AMETEK will restrict its participation in energy and trade shows.

ARCO Solar Industries

We have used both programs through ARCO Solar, Inc., and consider them both to be helpful.

Dr. Karl W. Böer

The question is not applicable.

Frederick Schmid, President  
Crystal Systems, Inc.

We have attended some DOE Export Promotion Seminars. We do not feel that these type of trade shows help us very much because we produce and market only silicon wafers, not finished PV cells, and these shows usually attract end users more than anything else.

Our company was in the April 1981 DOC Commercial News magazine. This type of promotional activity is important because it did not take much of the company's time or money and yet the message should reach a large number of potential customers.

DSET Laboratories, Inc.

We have used the DOE program. We attended the European Energy Event and found it very helpful. We developed many good business leads and opportunities as a result of this event. We have also attended other trade shows and events not sponsored by the U.S. Government at our own expense.

We have not participated in any DOC trade promotion events to date, and therefore cannot comment on them.

Exxon Enterprises

The DOE/DOC trade promotion programs and shows are helpful in educating potential customers that photovoltaic systems are a currently available energy option. Solar Power Corporation did not participate in the DOE European shows because it was already in business in 3 of the 4 countries and was preparing to enter the 4th.

Ford, Bacon & Davis Utah, Inc.

No, our work in the solar area has not yet given us an opportunity to use them. We are familiar with the programs but at present are not participating.

R. Douglas Wright, President  
Free Energy Systems, Inc.

We had no foreign market before attending the DOE/DOC European Energy Event in January 1981. These programs are beneficial, especially to small companies, and if at all possible, should be continued. Small businesses lack the capital, staff and time to seek out and take advantage of foreign market possibilities. These programs offer many opportunities to small U.S. businesses that would otherwise go largely to foreign companies.

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Dr. Peter E. Glaser

The question is not applicable.

John V. Goldsmith

No, we have used neither one.

Lockheed Missiles and Space Company

The question is not applicable.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

We have not used either program.

Motorola, Inc.  
Semiconductor Group

We have used both programs and consider them both very useful.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

We have not used the DOE program, but are familiar with it and think it is a good program. We were impressed with the results of the European Tour and plan to participate in the Latin American shows. We have not used the DOC program.

SES, Inc.

No, we have not used these programs.

SILTEC, Inc.

We have used neither program.

Spire Corporation

DOE's commercialization program looks good and we plan to use it in the future when our product is ready to market. We have already advertised in the DOC Commercial News that lists solar products. Trade shows are a way of getting exposure overseas, and lining up sales agents and customers.

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Robert W. Willis, President  
Solenergy Corporation

We have attended DOE export seminars. It was strange that the eight PV companies that already were established in foreign markets were also in attendance. We did not participate in DOE's European Event because we could not spare the time away from the business. The event would have helped and we do plan to attend the Mexico show. We have also attended other domestic trade shows, including one held by NASA-Lewis in Arizona.

Dr. Milo Macha, President  
Sollos, Inc.

We have used neither program, but are familiar with them.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

We have used neither program.

Varian Associates, Inc.

We have not used either program.

Westinghouse Electric Corporation

Westinghouse has not had the occasion to use either the Department of Energy or the Department of Commerce's export promotion programs.

Other comments

--We have used both programs and have found both very helpful. These programs are "a Godsend". The red tape to participate is a pain in the neck, but both programs have been very productive for us.

--We have used neither program.

--We have not used either program, we have had no need for them. We have participated in some private trade shows, and will be in the Solar Energy Exposition in Brighton, England, in August 1981.

--We have used neither program.

--We have used both programs, and found them to be effective and useful programs.

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7. Which foreign companies and countries are your chief competitors?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

France, Germany and Japan.

Anthony Adler

The question is not applicable.

AMETEK, Inc.

In solar thermal collectors, the Israelis and Japanese (very strong) are the chief competitors. In PV, the strongest competition comes from Germany and France. The Europeans think that the U.S. PV goal of 70 cents per peak watt by 1986 is wishful thinking. They are focusing on the short and near term markets of \$5 per peak watt, because they see over \$850 million in sales at that level. It should be noted that the Japanese are becoming very active in the PV field.

ARCO Solar Industries

France, Japan, and Germany.

Dr. Karl W. Böer

The chief competitors the United States faces are the French, Germans and the Japanese. The Japanese show the strongest threat.

Frederick Schmid, President  
Crystal Systems, Inc.

The Germans and the Japanese are the major competitors, but they are not as far along in the technology as the U.S. companies. However, they have the advantage of being more familiar with their market areas and how to do business there.

DSET Laboratories, Inc.

DSET is somewhat unique in this respect in that we do not manufacture a product per se. Generally, foreign governments, institutions, and universities represent our chief foreign competition...for example, Euratom-EEC at Ispra, Italy. However, in many respects, the U.S. Government is our biggest competitor both in the United States and abroad, i.e., the Federal laboratory system and continued support of the university sector while the same capabilities exist in the private sector.

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Exxon Enterprises

Photowatt International and France Photon of France, and AEG-Telefunken of Germany are the major competitors at this time. We anticipate that Japanese companies, such as Sanyo and Fuji, will be formidable competitors in the future.

Ford, Bacon & Davis Utah, Inc.

The question is not applicable since we have no foreign work. We anticipate strong competition from German firms (AEG-Telefunken and Siemens AG) and Dutch firms (Phillips GMBH).

R. Douglas Wright, President  
Free Energy Systems, Inc.

We consider the French and the Germans to be the strongest competitors.

Dr. Peter E. Glaser

The question is not applicable.

John V. Goldsmith

Japan, France, and Germany--Wacker and AEG-Telefunken have superior technology to other foreign firms but their price is high.

Lockheed Missiles and Space Company

The question is not applicable, we are in Government R&D only.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

We are not aware of any foreign competition in concentrator cells.

Motorola, Inc.  
Semiconductor Group

AEG-Telefunken of Germany and Radiotechnique-Compelec S.A. (RTC) of France are our chief competitors. We have not experienced much competition from Japan yet, but the Japanese are showing some signs of getting ready to make a big move into the PV market.

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Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

Photowatt has divided its markets among its subsidiary companies. Photowatt International, Inc., the U.S.-based company, markets primarily in the United States but does compete to a lesser extent in Europe and Africa. Its major export markets are South America and southeast Asia. Photowatt International, SA, the French-based company, markets primarily in Europe and to a lesser extent in Africa. Photowatt International Afrique, the Ivory Coast-based company, markets primarily in France's former colonies in Africa.

In this context, our greatest competition comes from Telefunken of Germany and a lot from Japan. The Japanese are very strong in Australia and South America.

SES, Inc.

We are not in the market, and consequently are unable to assess.

SILTEC, Inc.

Photowatt International and RTC of France; Wacker of West Germany. Both Photowatt and RTC buy silicon wafers rather than grow their own silicon ingots. The Wacker R&D program to develop silicon production facilities for photovoltaics was funded 100 percent by the German Government (\$80 million, 1975-1985).

Spire Corporation

We have no foreign competition yet, since we are the only company producing this type of equipment. France, Germany and Italy have shown interest in acquiring machines from Spire for producing cells and panels. The Japanese have not shown much interest.

Robert W. Willis, President  
Solenergy Corporation

RTC of France is the major foreign competitor, but Solenergy's chief competition in foreign markets comes from other U.S. companies. For example, France Photon is a U.S. company because it is a joint venture between Solarex (a U.S. firm) and a French company to market Solarex PV cells in French market areas. RTC has formed a new French company in a joint venture with CGE and Photowatt International of France. (See p. 158.)

Telefunken and Siemens of Germany are both active but are no real competition. There is no competition from Japan at

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present, but they are showing signs of getting ready to enter the market.

Dr. Milo Macha, President  
Sollos, Inc.

Telefunken of Germany and Ferranti Ltd., of the U.K.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

The French, Germans and Japanese are the major competitors, in that order. The Japanese are not a threat yet. They usually do not get involved in the early stages of technology development. They prefer to look for more mature markets.

Varian Associates, Inc.

No comment.

Westinghouse Electric Corporation

The French, Germans and Japanese appear to be the strongest competitors to U.S. firms.

Other comments

--France, Germany, and Japan are our major competitors now; and the United Kingdom is beginning to become a competitor. The primary German company is Telefunken; Siemens is just starting in the PV business. In the United Kingdom, Ferranti and British Petroleum have combined to form a joint venture in producing PV cells. The French are doing so extremely well in the PV industry, that a U.S. pull back in marketing effort and R&D effort will be disastrous. It will leave the field wide open for the French and the Germans, and the Japanese will be right behind them.

Solec Corporation, a Hawthorne, California, company, was just recently sold to Pilkington Brothers, Ltd., a United Kingdom glass manufacturer.

--Germany, France, and--to a lesser extent--the Japanese.

--Chief competitor is Photowatt International of France.

--Japan--very strong technically, financially, and is well established in international markets; Germany--very aggressive and supportive of its PV industry; France--not a major competitor as compared to the Japanese and Germans. The French will stick to their old colonies where the government provides the industry a lot of support.

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8. How do U.S. photovoltaic products compare with foreign products in terms of cost, performance, and quality?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

The U.S. is definitely ahead in terms of technology and cost effectiveness. For example, the collectors built by Maschinenfabrik Angsburg-Nurnberg AG, (MAN) of Germany on the IEA project in Spain are beautifully engineered and constructed, but appear to be very costly to build. It appears to be a classic case of German engineering overkill. Italian products are still crude -- first generation efforts. We do not know as much about the French. Some of their early systems have not worked very well.

Anthony Adler

U.S. products have the highest quality and reliability on the market. Cost is a function of government support, labor rates, etc. I suspect that U.S. PV products are the most expensive at the customer level.

AMETEK, Inc.

U.S. products are superior to foreign products in terms of cost, performance and quality in both solar thermal and PV. U.S. efforts at improvement must continue, however, or this situation could reverse.

ARCO Solar Industries

We believe that the U.S. PV products are superior to the foreign competition in every respect.

Dr. Karl W. Bør

It is difficult to compare U.S. PV products against foreign products without performing tests. I suspect that the United States leads in some PV technologies. This leadership, however, is either equalized or neutralized when compared to other countries' international commercial networks and government support of their industries.

Frederick Schmid, President  
Crystal Systems, Inc.

The United States is ahead in terms of cost, performance, and quality, but the foreign companies have several marketing advantages.

DSET Laboratories, Inc.

DSET is in an interesting position to answer this question. In our testing business we have had the opportunity to closely observe the performance of many different companies' PV products.

Many European companies buy U.S. PV cells and install them in their own panels, modules and arrays and sell the resulting system as a European product. As an alternative, some foreign companies buy U.S. PV cell-making technology, produce the cells themselves for use in their own panels, etc., and again market the final product as a European product. The PV systems resulting from these efforts appear better made than some U.S.-made panels. European and Japanese modules usually appear better engineered and more finished. However, with regard to performance and longterm durability, the "jury is out." European companies put more money and effort into final product design and finish than do U.S. companies. U.S. companies appear to concentrate more on applied R&D and on production with the result that the heart of the system, the PV cell itself and the encapsulation system, are often technically superior. However, this is often at the expense of appearance and product design. Foreign companies rely heavily on U.S. Government-funded work and thus can allocate funds to packaging and marketing.

One of the major strengths the U.S. has going for it right now is the Low-Cost PV Program being conducted by the Jet Propulsion Laboratory. It is an excellent program and should be continued.

Exxon Enterprises

U.S. PV products currently are superior in all three respects. Over the long run, we would expect products from major companies to be similar in nature and cost. Service, in addition to price, will become increasingly important.

Ford, Bacon & Davis Utah, Inc.

The foreign products compare favorably with U.S. products. The United States has the best equipment, but the foreigners compare favorably and are catching up. Prices are about the same. Foreign competitors have slightly better efficiencies in some cases. Their system approach and standardization seems to be somewhat more appealing to developing countries.

R. Douglas Wright, President  
Free Energy Systems, Inc.

U.S. PV products presently are superior to foreign products in cost, performance and quality. This may not last, however,

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if the United States loses the pace to further reduce price and increase efficiencies.

### Dr. Peter E. Glaser

PV systems being produced by the U.S. PV industry are technically more advanced, exhibit better performance and quality, and have costs that are competitive with foreign products. However, the competitive position of the U.S. PV industry is not favorable in those countries where foreign companies have, over the years, built up closer trading ties. For example, French companies can sell more easily in the former French colonies and Japanese trading companies have very close ties to South American and Middle Eastern countries. The Japanese Government views the foreign PV market as being important to its PV industry and close government-industry cooperation makes it easier for Japanese industry to penetrate foreign markets. In addition, industry in other countries is traditionally export minded and, therefore, more familiar with obtaining loans from the international financial institutions than is the U.S. PV industry.

### John V. Goldsmith

U.S. PV technology is the standard by which other countries compare their technology. Presently, the United States has certain PV products that are not available anywhere else in the world. Also, U.S. PV products cost less than anywhere else when you do not count foreign government subsidies. As far as quality, the Germany company, Telefunken, is probably the best.

### Lockheed Missiles and Space Company

No comment.

### Wesley G. Mathei, Manager Solor Products Division Microwave Associates, Inc.

Because there is no competition, you cannot make a comparison.

### Motorola, Inc. Semiconductor Group

It is a changing scene. The Europeans, especially RTC, are getting very close to the quality of U.S. products, although they are still higher on cost. Telefunken is still too high on cost, and has some performance problems. The Japanese are still an unknown quantity.

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Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

In general performance and quality, U.S. products are equal or better.

### SES, Inc.

U.S. PV products are considered among the best in the world. The foreign companies, nevertheless, are also developing and producing PV systems. If the foreign companies develop their systems and produce higher efficiencies and less costly PV cells, the U.S. companies are going to have strong competition. The foreign companies have the advantage of starting at a higher level of the learning curve, eliminating most of the basic R&D by using U.S.-developed knowledge and technology, and are able to devote a large effort, and funds, to fine-tuning the product. The Japanese are masters of this strategy and the United States can look to them first as being the strongest potential competitor.

Although the United States is looked upon as the leader in PV technology, it will not remain there if the industry reduces its efforts to pursue cost and efficiency improvements.

### SILTEC, Inc.

Currently, U.S. PV products hold a slight technology lead in terms of PV cell efficiency and are competitive in cost and quality.

### Spire Corporation

The United States has a good lead in all categories.

Robert W. Willis, President  
Solenergy Corporation

U.S. products are better in every way.

Dr. Milo Macha, President  
Sollos, Inc.

U.S. products are better in every respect.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

The U.S. products are more advanced in every respect.

Varian Associates, Inc.

No comment.

Westinghouse Electric Corporation

Right now the United States enjoys product advantages over foreign products in terms of cost, performance, and quality. However, this may be lost if the U.S. PV industry loses its momentum due to the significant budget cuts and redirections.

Other comments

--The United States is definitely ahead in quality; cost has been about the same.

--The United States has been way ahead in technology and cost. Others, however, are catching up in both areas.

--Our company has not made an assessment of U.S. products compared to foreign products. We think that the French and German products are improving, and the Japanese have a marketing advantage in their trading companies.

--U.S. PV products are better technically and in quality. Cost of foreign products is not clearly defined due to subsidies of foreign governments.

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9. What assistance do foreign companies receive from their governments that U.S. companies do not receive? How does this affect U.S. companies?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

See answer to question 10.

Anthony Adler

See response to question 10.

AMETEK, Inc.

AMETEK has no specific knowledge of what assistance foreign companies receive.

ARCO Solar Industries

Foreign companies receive support across the entire spectrum of activity--low cost subsidized export loans, direct price subsidy, and home country purchase preference. Their R&D and marketing efforts are coordinated in the country between competitors in a way that would be considered monopolistic by U.S. law.

Dr. Karl W. Böer

Other governments offer financial packages, export incentives and free trade shows (to mention just a few forms of government assistance) to encourage PV development and exports. This makes competition tough for the U.S. companies who do not have many of these advantages. I was also informed that a Japanese company plans to mark up the sales price of its PV products only 3 percent over cost. This will make competition even more difficult because U.S. companies need a higher profit margin, hence must produce a competitive product at even lower cost.

Frederick Schmid, President  
Crystal Systems, Inc.

Germany has made commitments to several large companies and Japan has put together a team of companies in its Project Sunshine. In both countries, selected companies are teamed together to solve technical problems. Vertical integration is not considered at this time.

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### DSET Laboratories, Inc.

(1) Foreign governments support their companies in terms of establishing joint objectives for government and industry in terms of international markets. (2) Foreign governments use industry members as advisors to government agencies and as members of teams attending international conferences and meetings. (3) Foreign governments tie their foreign assistance to their own country's products, in direct contrast to the way the United States gives foreign assistance. During a recent trip to Europe, we learned that the United States provided funds to Egypt to develop energy production facilities without tying the funds to the requirement to purchase the equipment from the United States. Egypt purchased all the project equipment and services from a Central European country whose government had actively solicited this business from Egypt on behalf of its companies--all in contrast with the U.S. Government which did little or nothing to promote the interests of its own companies. (4) This approach to international cooperation in energy technology puts U.S. companies at a disadvantage.

### Exxon Enterprises

The French Government, for example, supported one French company by committing to purchase 60 percent of its output. French Government officials, and particularly the French Foreign Service, have been able to secure information about sales opportunities very early and feed this information back to French companies. In addition, the French and German Governments often intervene directly through their respective foreign services to promote sales of their national manufacturers. This may be relatively easy where there are only one or two manufacturers, but is much more difficult when there are several firms, as is the case in the United States.

### Ford, Bacon & Davis Utah, Inc.

Foreign companies receive (1) direct support from the diplomatic representations in all countries, (2) government-funded trade shows permitting participation without cost other than related travel cost (equipment shipped free, etc.), and (3) very attractive financing and credit terms as well as non-payment risk insurance.

### R. Douglas Wright, President Free Energy Systems, Inc.

We are not familiar with what foreign governments give their companies, except that the French Government will arrange attractive financing for potential buyers and provides funding up front for R&D and export activities.

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### Dr. Peter E. Glaser

The close cooperation between government and industry in other countries is being increasingly recognized as detrimental to the export efforts of U.S. companies. This factor does not apply solely to the U.S. PV industry but is a much broader issue which handicaps U.S. industry when dealing with foreign competitors.

### John V. Goldsmith

The U.S. Government will not help develop near-term production engineering as the other governments do because it does not want to support commercializing products. The closest the U.S. Government comes to assisting commercialization is when it has made fixed price block purchases of advanced technology to stimulate its development.

European companies, on the other hand, are heavily subsidized by their governments in developing and commercializing technology as well as research.

### Lockheed Missiles and Space Company

No comment.

### Wesley G. Mathei, Manager Solar Products Division Microwave Associates, Inc.

No information.

### Motorola, Inc. Semiconductor Group

The German Government gives free systems to LDC governments to create a market for German systems. Germany and France each support only a limited number of companies in their industries and designate their areas of major effort to reduce internal competition which they consider to be wasted effort and money. The European and Japanese governments also take a very active role in selling products for their companies to the host government. U.S. commercial and economic staff in embassies will provide a host government or foreign party a list of U.S. companies in the PV business, but they will not sell for U.S. companies or make contractual commitments like their foreign counterparts do.

The thing that will sell solar energy devices in LDCs is actual on-site demonstrations of a working system so the potential customer can observe how it works, that it performs well and is reliable. For example, Motorola initiated contacts with a foreign government and generated a sale for a communication power system. The customer, however, required that the system be installed and

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operated successfully for one year before accepting and paying for it. The same LDC government had also agreed to cost share with the U.S. Government four Motorola village PV power systems as a demonstration project. This agreement, however, was over a year in negotiation. In the meantime, the French have donated and installed a village power system. With the budget cuts, we doubt that the U.S. systems will ever be installed.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

The French Government is a very strong partner with its industry. The French establish contacts with foreign governments at the ministry level in order to develop and secure business for their companies. The Germans operate in a similar way, and, in addition, the German Government gives away free demonstration projects to LDC governments in order to create an entree' for its companies.

SES, Inc.

No comment.

SILTEC, Inc.

Foreign companies receive large block grants for technology development. This creates disadvantages for U.S. companies, who must use mostly their own capital for marketing and development.

Spire Corporation

We think the foreign governments' level of research funding has been proportionately higher.

Robert W. Willis, President  
Solenergy Corporation

The German Government gave one of its companies, Wacker, \$40 million for material development. Companies in the European Economic Community countries get substantial support in getting European business which U.S. companies are cut out of unless they form a joint venture with a European company.

Dr. Milo Macha, President  
Sollos, Inc.

We do not have a good feel for this subject. We know, however, that Ferranti is owned 50 percent by the British Government.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Foreign firms receive more extensive marketing and financing assistance.

Varian Associates, Inc.

No comment.

Westinghouse Electric Corporation

Not enough information to comment.

Other comments

--Foreign companies receive moral support and direct government help in everything from R&D to keeping out foreign competition to marketing development. Wacker received 75 million Deutsche Marks from the German Government to get started in the solar energy business. Likewise, Telefunken received a large amount of money to set up a plant. The French have set up an entire government ministry just for solar energy. The foreign governments also finance numerous foreign demonstration projects which serve to demonstrate feasibility and generate market pull in foreign countries.

--Foreign companies receive assistance in two areas:  
(1) The foreign government often directs work and reduces internal competition within its country. For example, the German Government has designated Telefunken to be the producer of PV cells in Germany. They have designated Wacker to be the manufacturer and supplier of silicon. The government has even established long-term contract goals for these companies. Japan operates in a very similar way, as does France. (2) These companies receive direct subsidies from their governments. For example, we have found that whenever we find ourselves bidding against Telefunken, the German Government will subsidize Telefunken's bid to the point that Telefunken will be the lower bidder. We can cite specific cases.

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10. What role do foreign governments play in developing markets for their companies?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

In addition to answers already given to other questions, other countries have a much closer government, industry, and financial community relationship than does the United States. For example, on the IEA Small Solar Power Systems Project in Spain Acurex easily won the design phase because we had a lot of similar experience in the United States. From that point on, however, we had a constant battle to stay involved in the project ~~mainly~~ due to heavy pressure put on the IEA by the German Government to use German companies. We called upon DOE to counteract this pressure. DOE did successfully counter the German pressure, but it took lots of urging and pushing from Acurex to get DOE to do it. In sum, the Germans, specifically, are much more serious about foreign marketing than is the U.S. Government.

Anthony Adler

The French Government is providing support to its PV industry by financing sales at low interest loans or sometimes at no interest. The United States has lost \$12 to \$15 million in sales because of the French financing program. Another factor is that the French sales are going to their former colonies. Japan is making a major government effort to accelerate the development of photovoltaics.

AMETEK, Inc.

No comment.

ARCO Solar Industries

Foreign governments provide low interest loans and subsidized demonstration projects.

Dr. Karl W. Böer

See response to question 9.

Frederick Schmid, President  
Crystal Systems, Inc.

No comment.

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DSET Laboratories, Inc.

Above all else, foreign governments lay the conduit for their companies to acquire follow-up business and sales. Their role is planned and calculated in contrast to U.S. Government roles which are too often only fortuitous when successful.

Exxon Enterprises

In addition to the response given in Question 9, the German Government has aided its industry by making many gifts of German products to prospective customers especially when the German manufacturer is in competition with a U.S. photovoltaic manufacturer.

To date, we have not seen much of the Japanese in the foreign photovoltaic market.

Ford, Bacon & Davis Utah, Inc.

Foreign companies can work together. The U.S. antitrust legislation prohibits U.S. companies from collaborating on large projects. Foreign governments work much better at commercializing the results of new research. The United States and its companies win lots of Nobel Prizes for R&D, but do not commercialize these ideas. Excessive U.S. Government regulations which stifle change and innovation may have some effect on capability to commercialize. Foreign diplomatic representations become the immediate supporters of their domestic industries by actively introducing business parties and initiating first contacts. They advise about business parties in a foreign country mostly through the economic sections in their embassies.

R. Douglas Wright, President  
Free Energy Systems, Inc.

We are not familiar with this subject, except that the French Government offers attractive financing at low interest rates and provides funds up front for R&D and export activities.

Dr. Peter E. Glaser

Several foreign governments plan with their industries on how to develop technology that will be competitive in foreign markets, establish joint industry programs to achieve these plans, and in the absence of anti-trust laws, permit industries to work together to mutual advantage. For example, Japan in its Sunshine Project, has periodic meetings between the Ministry of International Trade and Industry (MITI) and industry. The decision of the Japanese PV industry to focus on amorphous silicon was reached through cooperative government-industry decision making. In France, COMES is guiding the French industry PV development effort, and the French

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PV industry structure, which involves major industrial organizations, is designed to produce PV systems competitive in foreign markets.

John V. Goldsmith

The foreign governments help local companies sell their technology.

Lockheed Missiles and Space Company

No information.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

No comment.

Motorola, Inc.  
Semiconductor Group

See answer to No. 9.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

Answered in No. 9.

SES, Inc.

No comment.

SILTEC, Inc.

West Germany and France have provided trade agreements, which make available low cost loans to other countries for purchase of PV systems. Support is given for setting up and operating demonstration PV systems for various applications.

Spire Corporation

No comment.

Robert W. Willis, President  
Solenergy Corporation

The French Government buys the output of RTC at substantially higher prices than U.S. prices.

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Dr. Milo Macha, President  
Sollos, Inc.

We have no knowledge of this subject.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

No comment.

Varian Associates, Inc.

No comment.

Westinghouse Electric Corporation

Not enough information to comment.

Other comments

--In addition to the answer to question 9, foreign governments use their embassies to do marketing for their companies, and they pay for foreign demonstration projects.

--In addition to the answer to question 9, France very actively solicits markets for its individual companies through government-to-government agreements, especially in Africa. Japan also operates in much the same way.

--The European and Japanese governments play strong roles in developing markets for both their new and established companies. Furthermore, these governments provide strong financial support for R&D and installation of demonstration projects in foreign markets. As a result, we are always being asked for free demonstration projects by prospective foreign customers.

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11. How do the capital needs of foreign companies compare with the capital needs of U.S. companies of similar size and activity? In other words, does the support of the foreign company's host government in developing markets, exporting products, or whatever it does, significantly reduce the capital needs of the foreign company?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

We are not sure of the capital needs of foreign companies, but the activities of the foreign governments definitely have to be a big help to their companies. Any time you have your government giving away a system to open up a market it means that much less expense and effort that individual companies have to go through to develop that market.

Anthony Adler

The government role does change their companies' capital needs. The company does not have to finance its sales because it is given government financing to enter the market.

AMETEK, Inc.

Foreign government support for their companies in developing markets and exporting products does reduce those companies' capital needs.

ARCO Solar Industries

Not to our knowledge.

Dr. Karl W. Böer

No comment.

Frederick Schmid, President  
Crystal Systems, Inc.

It reduces it by financing the company's R&D efforts.

DSET Laboratories, Inc.

As discussed in 9 and 10, capital needs would appear to be less for foreign companies.

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Exxon Enterprises

The private capital requirements of foreign companies are about the same as for U.S. companies. The only advantage any foreign company may have had was when its government agreed to purchase a certain amount of product at a relatively high price. This boost in sales revenue may have made it easier for the company to raise needed funds.

Ford, Bacon & Davis Utah, Inc.

The answer is probably yes. In recent years, foreign companies have moved into markets all over the world and become more cosmopolitan than U.S. companies which traditionally were good at this.

R. Douglas Wright, President  
Free Energy Systems, Inc.

Capital needs of U.S. and foreign firms are the same if the companies want to remain competitive and expand into other markets. What separates U.S. firms' capital needs from their foreign competition is access to those funds at a favorable interest rate with minimal strings attached. There is no doubt that other governments work closely with their companies to make stronger competition for the United States. Consequently, this probably results in special loan arrangements for the foreign companies, if not outright write-offs.

Dr. Peter E. Glaser

No comment.

John V. Goldsmith

We don't know much about foreign capital needs, but it seems logical that the government assistance must reduce the companies' capital needs.

Lockheed Missiles and Space Company

No information.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

No comment.

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Motorola, Inc.  
Semiconductor Group

We have been pleased with the DOE R&D budget so far.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

We do not think there is a real difference. The foreign government role is to primarily provide markets, but it probably does effect costs.

SES, Inc.

No comment.

SILTEC, Inc.

See answer to No. 10.

Spire Corporation

We feel that the government support is stronger in Germany and France. However, this is a hard thing to quantify.

Robert W. Willis, President  
Solenergy Corporation

Foreign companies' needs will not be any different than U.S. companies, but their access to capital is easier. In foreign countries, you can get government financing to start a business--even a risky business.

The French Government's COMES will guarantee subsidies for PV companies.

Dr. Milo Macha, President  
Sollos, Inc.

No comment.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

No comment.

Varian Associates, Inc.

Varian is not really in a position to answer this question. However, the EEC, is starting a big PV program and in soliciting

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information and bids on this program, the comparison of system costs proposed by the Germans and the French are very comparable to the system costs of U.S. companies. However, a big difference is that the European governments have a government-to-government agreement with many LDCs to install and demonstrate their PV systems in those countries using government money. So in this sense the capital needs of foreign companies to develop a market would be considerably less than the needs of U.S. companies if the U.S. Government does not similarly demonstrate its systems. As an example, France in 1980 provided \$25 million in subsidies to help the PV industry compete with U.S. companies for international contracts.

### Westinghouse Electric Corporation

Since the foreign governments are behind their respective companies to develop PV and export the technology, no doubt access to capital is easier for them than for U.S. companies. As far as capital needs go, any company, domestic or foreign, planning to manufacture and sell the technology will have to have significant amounts of funds to get to commercialization.

### Other comments

--Foreign companies' capital needs are probably similar to those of U.S. companies, but the government assistance they receive makes their market development budgets go that much farther. Also, having the prestige of their home government backing them carries a lot of clout with potential customer LDC governments.

--U.S. and foreign companies have similar needs for capital. However, U.S. companies are at a disadvantage in this regard, because a foreign government will subsidize a promising technology all the way to market.

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12. Are foreign companies or governments developing their photovoltaic technology at a faster rate than is the United States?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

We do not think foreign technology is developing faster than that of the United States.

Anthony Adler

The Japanese Government is spending between \$50 and \$100 million on amorphous silicon R&D work. They are already regularly producing sheets of amorphous silicon. Their only problem is that the efficiency is only 3 percent. Because of this, they are currently using PV for only small device applications like watches, calculators, etc. There is no question that Japan is making considerable progress, but we are helping them. When a U.S. company gets DOE R&D funds, the knowledge developed becomes public domain for the world. DOE will not license the technology unless the company goes commercial with it. The fact that the U.S. Government gives away our knowledge and technology is a very serious problem and could adversely affect our world leadership in photovoltaics. We could very easily be put in a dependency position vis-a-vis Japan in photovoltaics just as we are with OPEC in oil.

ARCO Solar Industries

We are not certain that it is faster but there is considerable progress being made overseas.

AMETEK, Inc.

Sanyo, a Japanese firm, has committed \$50 million to mass production of amorphous silicon PV cells for watches, calculators and toys. U.S. industry should keep an eye on them because Sanyo could enter the larger markets at a full pace since its international marketing channels are well-established.

Dr. Karl W. Böer

The French and Japanese are actively pursuing the development of PV technology and compete with U.S. companies in the international marketplace.

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Frederick Schmid, President  
Crystal Systems, Inc.

Foreign companies are pursuing markets in underdeveloped countries much more aggressively than we are. In many cases, they already have ties in these countries.

DSET Laboratories, Inc.

We think they are! The foreign companies are building their PV development upon a base of prior and current U.S. PV research and development work, which is freely shared by U.S. agencies and universities. Since the foreign companies do not have to repeat the basic R&D and follow dead ends, they have started much further along the learning curve than did the United States. Also, most U.S. companies are still concentrating on development and production rather than on sales. Most foreign firms are concentrating on producing and marketing current technology to build and expand future international markets, while concurrently engaging in R&D aided by U.S. technology. This is giving the foreign companies the advantage of entering the market ahead of most U.S. companies. Thus, when the cost does come down and the international market (including the U.S. domestic market) begins to really take off, the foreign firms will be already on the scene ready to move with market demand. The U.S. companies will be trying to catch up--they may have the best products, but most of the world will not care.

Exxon Enterprises

Not to our knowledge.

Ford, Bacon & Davis Utah, Inc.

We do not think so, but if the United States slows down that might change. On the other hand, if the U.S. Government significantly reduces its expenditures on PV, the major companies with capital, such as oil companies, might carry the industry for their investments. We do not really see a conflict between the oil industry and nuclear industry and PV as competing technologies. We see a need for all three and believe that the oil companies will probably develop the PV industry and technology as rapidly as they are able to.

R. Douglas Wright, President  
Free Energy Systems, Inc.

No comment.

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### Dr. Peter E. Glaser

Government and industry in France, Germany and Japan are committed to developing PV technology. In the United States Government and industry should not be cutting back on R&D right now, but should be concentrating on advanced PV technology. The Japanese and several European industrial firms are developing PV technologies that are advanced compared to single crystal silicon. Single crystal silicon solar cells will most likely be displaced by thin film PV materials during the next ten years. Amorphous silicon, on which the Japanese are concentrating their R&D, may be the second generation PV material. The U.S. PV industry may lose the foreign markets, or a good part of them, if it does not take concerted action. The U.S. PV industry needs to plan the development and marketing of PV systems in foreign countries. For example, it must consider that higher U.S. labor rates may force them to manufacture overseas. Eventually, the PV market will be in the United States but by then, as in the case of the electronics industry, we may not be producing PV systems here.

### John V. Goldsmith

U.S. companies will do very well against European companies. However, Japan is a sleeper. Right now, Japan is not very competitive in PV, but could be a threat if it can duplicate in PV the industrial development it did in the transistor and semiconductor industries.

### Lockheed Missiles and Space Company

See response to question 4.

### Wesley G. Mathei, Manager Solar Products Division Microwave Associates, Inc.

No comment.

### Motorola, Inc. Semiconductor Group

No, the United States is moving faster except possibly for the Japanese and their amorphous silicon work. We would guess that in 5 years there will be only six major PV cell producers in the world and five of them will be U.S. The French are putting money into foreign universities (foreign to France) for R&D work as a slick way of tapping into other countries' technology. Both the French and the Italian governments are seeking to buy U.S. PV companies.

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Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

No, except maybe for the Japanese. The Europeans are at least a year behind.

SES, Inc.

No comment.

SILTEC, Inc.

Currently, U.S. technology is slightly ahead. If U.S. Government technology development funding is cut, foreign companies will most likely pass the U.S. companies.

Spire Corporation

Foreign firms are not developing their PV technology any faster than is the United States. They are all behind the United States now but the next couple of years will be critical. The French, Germans, Belgians, and Italians are all interested and working hard on PV R&D.

Robert W. Willis, President  
Solenergy Corporation

The United States is way ahead of the others. JPL has very competent staff.

Dr. Milo Macha, President  
Sollos, Inc.

No.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Not enough information to comment.

Varian Associates, Inc.

In the past this has not been the case. The United States is clearly the leader in PV technology. However, deep budget cuts in the Federal programs may change this situation. There is one exception to the situation of the United States being the leader and that is that the European countries of France and Germany are taking more of a systems approach in developing their PV technology than is the United States. An example would be the fact that

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they have designed irrigation pumps solely to work with PV systems, that is, they operate on direct current.

### Westinghouse Electric Corporation

We are not sure of the pace at which foreign companies or governments are developing their PV technology, but the United States should keep an eye on Japan since it is expert at developing and marketing technology in the United States.

### Other comments

--As of right now, no, they are not. In the future, after the U.S. budget cuts, they probably will.

--Not yet. The United States has been outspending the other countries on R&D. The Reagan budget may change this.

--The Japanese effort in PV is growing. They are funding R&D, which is unique since Japan usually gets in the market further down the road. We feel that Japan will be a strong competitor in the future.

--No, we don't believe they are.

--Currently, no foreign company is developing either solar thermal electric or PV technology faster than are U.S. companies.

APPENDIX II

13. How do U.S. marketing methods compare with those of foreign competitors?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Answered in previous questions.

Anthony Adler

The difference is export financing. Japan has developed its markets because (1) it has a good product and stresses quality control, and (2) its government supplies money to assist in marketing. U.S. PV products are of better quality, but the companies do not have the dollars to both market them and finance sales. It is important to have money to get into the market. Furthermore, when Japan decides to support a product it does it all the way. The Japanese Government usually owns a share in the company and thus profits directly by pushing the marketing of the product.

Most U.S. Government officials have not been in private industry and do not know what is best for private companies. The major key is to provide sufficient financing and capital for the companies and let the private companies make the sales.

AMETEK, Inc.

No comment.

ARCO Solar Industries

The marketing and distribution systems that ARCO Solar is now putting in place will be superior in sales coverage and service to any competitors.

Dr. Karl W. Böer

No comment.

Frederick Schmid, President  
Crystal Systems, Inc.

Ours are not as aggressive.

DSET Laboratories, Inc.

As mentioned before, foreign companies are generally ahead of the United States in marketing methods and are deeper into the marketing mode. With certain exceptions, the U.S. industry appears to be still oriented toward product development and production rather than market development.

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Exxon Enterprises

We see little difference, although in some cases the fact that a foreign company already has a distribution network for other products can be an advantage.

Ford, Bacon & Davis Utah, Inc.

They are different. Foreign companies have more freedom in adjusting to local business practices. This has not been a particular problem in the case of PV, however. It is a problem in big power projects that take lots of capital and involve lots of risk. Foreign competitors usually have multilingual staff and sales aids. Foreign competitors show a more concerted effort in selling abroad by continuing, for instance, visits of heads of state with extensive sales promotion campaigns.

R. Douglas, President  
Free Energy Systems, Inc.

U.S. companies have to market their goods through whatever channels are identified as being most effective for that company, whereas foreign companies work hand-in-hand with their governments to gain access to and develop foreign markets. Foreign governments also provide trade shows to expose the products to host country consumers.

Dr. Peter E. Glaser

Foreign companies do not have to worry about anti-trust laws, they tend to have closer commercial ties to specific countries, and their governments' export efforts are integrated with their industry efforts.

John V. Goldsmith

The major difference is the more aggressive role the governments play in market development. In photovoltaics, the U.S. Government has played a much more passive role.

Lockheed Missiles and Space Company

Not enough information to comment.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

No comment.

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### Motorola, Inc. Semiconductor Group

In terms of marketing, U.S. companies and the U.S. Government are relative neophytes. U.S. solar energy companies, except Motorola and Westinghouse, are new to foreign marketing and exporting of components and systems. It also does not help that the U.S. PV industry is developing in reverse order of the usual process of developing a domestic market first and then moving into foreign markets.

### Robert W. McGinnis Vice President and General Manager Photowatt International, Inc.

Foreign governments take a direct role in marketing products of their companies.

### SES, Inc.

No comment.

### SILTEC, Inc.

Currently, U.S. companies are concentrating more on the smaller market of communication applications (e.g., microwave sites), while foreign competitors are aggressively pursuing the potentially vast markets of third world country gridless areas. While the U.S. exports a relatively small portion of its PV production, France and Germany export approximately 80 to 90 percent of their total PV production.

### Spire Corporation

The foreign companies are doing a better job of marketing because they have the support of their governments, including, in one case, purchasing the company's production for resale overseas.

### Robert W. Willis, President Solenergy Corporation

We think the United States is ahead in marketing because it has better products. JPL is seen as the leader in solar technology. We can bring foreign businessmen to the United States and arrange meetings for them with JPL. This always impresses them. Because foreign governments are not seen as the leader in the technology, they do not have this advantage. U.S. companies are just as clever as their Japanese and European counterparts in marketing. Right now, the United States is ahead of them.

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Dr. Milo Macha, President  
Sollos, Inc.

Not enough information to comment.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Not enough information to comment.

Varian Associates, Inc.

No comment.

Westinghouse Electric Corporation

Not prepared to comment.

Other comments

--The U.S. is way behind in marketing methods. Often we do not even know how to do business in LDCs, while the foreign firms have been there for years and have an established market network.

--They both use similar methods, but the foreign companies already have the sales network in place.

--Foreign competitors have an advantage in dealing in foreign sales. Payoffs, or paybacks, are not forbidden as they are in U.S. companies.

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14. Do U.S. companies face marketing barriers that foreign companies do not?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

In addition to previous answers, local customs on bribery can be a problem. Acurex has not encountered bribery situations and would avoid doing business in such situations. Since we have been unsuccessful at developing business in many countries, perhaps we have encountered situations where bribes were expected and were too naive to recognize it.

Anthony Adler

U.S. companies face unique marketing barriers only in financing sales.

AMETEK, Inc.

No comment.

ARCO Solar Industries

No comment.

Dr. Karl W. Böer

No comment.

Frederick Schmid, President  
Crystal Systems, Inc.

U.S. companies have insufficient knowledge of foreign markets.

DSET Laboratories, Inc.

U.S. Federal support of international standards for photovoltaics under the auspices of the U.S. National Committee for the International Electrotechnical Commission (IEC) is essential or de facto barriers to U.S. international marketing will be erected. U.S. industry cannot afford to participate without financial support.

Exxon Enterprises

Yes, U.S. firms do encounter such barriers in some countries. For example, U.S. companies have difficulty marketing in countries with associate status in the EEC. We also encounter tariff

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barriers established to protect local manufacture, but this is common in many countries and presumably, such tariff barriers affect both U.S. and foreign companies which do not have local manufacture. The activity of some European governments in direct support of their industries, particularly in areas which were formerly colonies of these countries, often creates an artificial market barrier for U.S. companies. An example of this is the tariff preference to Societe Francaise des Photopiles in the Ivory Coast.

### Ford, Bacon & Davis Utah, Inc.

We are not aware of marketing barriers other than rules and regulations imposed by U.S. agencies that are peculiar to only the United States.

### R. Douglas Wright, President Free Energy Systems, Inc.

U.S. companies do not face any additional market barriers than do foreign companies because PV products serve a specialty market. U.S. companies may face institutional and tax regulation but this will not hinder U.S. competitive efforts.

### Dr. Peter E. Glaser

A major barrier to international marketing in developing countries, both for U.S. and foreign companies, is the lack of capital available to the buyer. The need for PV systems is in the villages, but they have no funds. This foreign market needs external financing, and this financing has to be supplied through loans, e.g., Export-Import Bank. One cannot market overseas in the LDCs like in the United States. Another barrier is the exclusionary policies of some foreign governments, such as India's which requires that a foreign company must build a manufacturing plant in India in order to market there. Foreign companies, therefore, are considering PV manufacturing plants in LDC marketing areas to meet such government requirements and to take advantage of low labor rates. As stated earlier, the U.S. PV industry may also find it necessary to shift PV production to LDCs and countries that have low labor rates.

### John V. Goldsmith

Market barriers that U.S. companies face in foreign countries vary from country to country. The most common are selective favored nation treatment, cultural and language differences, and trade agreements.

### Lockheed Missiles and Space Company

No comment.

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Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

No comment.

Motorola, Inc.  
Semiconductor Group

Barriers facing U.S. companies as opposed to foreign companies are (1) traditional market ties, (2) language barriers, and (3) cultural differences.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

Yes, to a degree. For instance, U.S. legislation, the Corrupt Practices Act and others, slows down some U.S. companies. Also many of the European companies enjoy old, long-established relationships with LDCs, especially their former colonies. This is a barrier to U.S. penetration of that market.

SES, Inc.

Difficult to assess for reason given in answer 7.

SILTEC, Inc.

European countries have the advantage of past colonial ties to Third World countries, mostly in the African continent, which provides them with a preferential marketing position.

Spire Corporation

We are very new to foreign marketing and have not encountered any barriers yet. Because our product is the equipment used to manufacture PV cells, some of our better customers may be the countries that want to exclude foreign PV producers from their markets.

Robert W. Willis, President  
Solenergy Corporation

Marketing barriers are usually faced equally by all producers, regardless of where they come from. For example, Spain recently imposed a 35-percent import duty on all solar energy products. This is a barrier, but it applies to all companies, U.S., German, Japanese, etc.

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Dr. Milo Macha, President  
Sollos, Inc.

No comment.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Not enough information to comment.

Varian Associates, Inc.

We are not aware of any such barriers.

Westinghouse Electric Corporation

Not prepared to comment.

Other comments

--The United States is not welcome in many countries. In addition, there are language barriers.

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15. How will the budget cuts affect the U.S. PV industry's ability to compete in foreign markets? How will it affect your company? Can the industry (and your company) make it on its own without Government help? Which companies can or cannot make it on their own? Where do they need help?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

If R&D is cut back, it may hurt the ability of the industry to quickly reach the point at which PV cell cost reduction can be achieved. This would be a mistake. It will not have an immediate effect on Acurex. If the cost reduction period is stretched out, however, this will hurt our and other companies' ability to offer low cost PV systems and compete with other energy forms.

The U.S. industry still needs help in the form of PV and point focus R&D funds. It also needs Government loan guarantees, tax credits, etc., to help create a market for near-term technology. The Government should not buy PV systems itself to create a market unless they are genuinely cost effective. Congress should stimulate commercialization of near-term technology. The work done to date in PV is infinitesimally small compared to even the near term potential. The middle to long term potential is simply vast.

Anthony Adler

If the Government cuts back on near term development work, it could delay domestic commercialization as much as 5 years. The industry has developed its growth plans around the Photovoltaic Act and the 10 year Federal expenditure of \$1.5 billion. Industry did not count on all of the \$1.5 billion being spent, but it did count on Government support for a strong industry by 1986. The price goals were based on this assumption. The price goals are really volume goals, which would mean that by 1986 we would have production capability of 20 megawatts.

There could be negative effects from the Government withdrawal from near term R&D. RCA, for example, is looking for support of its research. If the Government withdraws, RCA might not take on that R&D. In other words, the R&D work may be put on the back burner. Further, the less development and near term oriented our program is, the more likely we will fall prey to Japanese technology.

AMETEK, Inc.

No comment.

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ARCO Solar Industries

See response to question 18.

Dr. Karl W. Böer

No comment.

Frederick Schmid, President  
Crystal Systems, Inc.

It will slow down market penetration. We do not know whether our company will make it without Government help, but certainly hope so. This will be a very critical time because we are seeking private capital in order to go into the next phase--prototype production.

DSET Laboratories, Inc.

Answered in response to questions 1 and 2.

Exxon Enterprises

We see essentially no effect of the budget cuts on our ability to compete in foreign or domestic markets. The cuts could affect companies who conduct research primarily through Government funding.

Ford, Bacon & Davis Utah, Inc.

The budget cuts will probably slow the entry of the U.S. industry into foreign markets, including Ford, Bacon & Davis.

The U.S. PV industry cannot make it on its own yet without Government help. It still needs some Government risk-taking help and funds, as the private market is still not large enough.

Large companies that can draw funds from other activities, such as those PV companies owned by major oil companies, will survive. Small independent companies that rely strongly upon U.S. Government funds may go broke.

R. Douglas Wright, President  
Free Energy Systems, Inc.

The budget cuts will not directly affect us one way or the other, as the company was not built on Government funding and is not dependent in any way on Government funds.

Dr. Peter E. Glaser

No comment other than that the Government should not be cutting back on PV R&D.

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John V. Goldsmith

(a) The large and growing U.S. budget had indicated a U.S. interest that helped foreign marketing. The Reagan budget cuts are having the opposite effect. Furthermore, other countries may also follow in cutting their PV budgets because they see the United States showing disinterest.

(b) World perception of U.S. Government actions will reduce sales.

(c) Yes, but will be commercially oriented rather than national interest (alternative energy source) oriented.

(d) Those tied to Government funding will not survive.

Lockheed Missiles and Space Company

We can not comment since we are not marketing PV products, only performing Government-funded R&D work. Lockheed will not continue the R&D projects if Government funding terminates. Right now, Lockheed has two DOE funded programs - cadmium sulfide/copper sulfide R&D and amorphous silicon magnetron sputtering process R&D. DOE discontinued both of these contracts upon expiration of the current contracts in July 1981. We regard this as very unfortunate as we are just reaching the point of making real progress, especially in the amorphous silicon work. We consider amorphous silicon to be the credible answer to PV low cost production.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

The cuts will effect which R&D work will be done by this company. DOE will also have to make choices and fund only the relatively more promising technologies. Those which we do not feel worth additional funding are metal oxide, zinc oxide, and some of the other oxides, cadmium sulfide, and amorphous silicon. We would not invest in amorphous silicon because we do not see it becoming any more than just competitive with current technology. It must be better than current technology before it is worth investing in.

Motorola, Inc.  
Semiconductor Group

Yes, the cuts will affect the U.S. industry. The small companies will have a lot of trouble.

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Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

Major cuts in R&D will hurt the U.S. position in the future, especially in the next 10 years. Japan, France, and Germany are very serious about getting into these markets and are consistently pursuing them with vigor, as opposed to the on-again, off-again U.S. approach. With the current approach, the United States may not even stay in the PV business.

SES, Inc.

The budget cuts will not effect SES' ability to compete in foreign markets if we go into production. (See question 1.)

SILTEC, Inc.

The budget cuts will cause loss of technology development at a satisfactory pace to be competitive and subsequent substantial loss of market share in an increasingly expanding market.

SILTEC does not have the resources to internally fund PV R&D efforts and would cease all PV technology development if we were to receive no more Government funding.

The industry and SILTEC must have external funding in order to continue PV technology development.

The PV companies that can make it on their own are those owned by the large oil companies; other companies will find it difficult to survive without help.

The help needed is the continuation of the technology development portion (TD&A) of the PV Energy Systems. This is the most critical need for the next two to three years.

Spire Corporation

The budget cuts will hurt the ability of the smaller companies to get exposure in foreign markets. Smaller companies face a lot of demands for their limited capital and it is expensive to market overseas. Trade shows help in getting foreign market exposure, and it will be difficult for small companies to accomplish this without the Government programs.

Robert W. Willis, President  
Solenergy Corporation

The real question is whether the big companies now supporting small PV companies will continue to support them if the Government effort is cut back.

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We know that the PV budget cuts were being based on the assumption that the technology is near term, and not because the Government feels that it is not worth supporting, but that is not the impression that people are getting. People see the budget being cut and equate that with the Government pulling out of the technology. Without Government support, companies will wait until the cost goals are reached before making major investments.

Many small companies that live on Government contracts will fold. Some other companies on shaky ground also might not make it.

### Dr. Milo Macha, President Sollos, Inc.

The budget cuts will definitely slow the industry's ability to compete in foreign markets, but it will not affect Sollos at all. Government funds have never helped Sollos in the first place, so their absence will not be noticed.

The industry can make it without Government funding, but at a slower pace.

### Ronald S. Scharlack, Manager Solar Systems Thermo Electron Corporation

No comment on the industry as a whole. We do not see a viable PV market in LDCs due to the lack of buyer capital, and are not competing in the foreign market itself. Therefore, we do not believe the budget cuts in foreign marketing will affect our own operations very much.

### Varian Associates, Inc.

Since Varian is not in the foreign market, the answer here is purely from impressions. Basically, most of this question does not apply to us. However, the 1981 PV market is somewhere in the range of 5 megawatts which translates to only about \$70 million. The budget cuts will definitely slow or reduce the ability of the U.S. industry to compete in the foreign market. In terms of affecting Varian as a company, it will not affect us.

However, if we do not receive Government support for the R&D work we are conducting, we would not continue in PV R&D work entirely with corporate funds, as the risk is too great and the payback period is too long.

### Westinghouse Electric Corporation

Westinghouse has made no effort to assess the effects of budget cuts on the ability of the photovoltaic industry to compete in foreign markets.

Other comments

--The cuts will hurt future growth more than current markets. Cutbacks in R&D will have a disastrous effect upon the U.S. future in the industry.

It will affect our company by losing immediate potential sales in the demonstration projects in Mexico and Italy. It will slow R&D since 100 percent of the company's R&D expenditures have come from U.S. Government R&D contracts. The company will survive but will develop at a much slower rate.

The U.S. industry can also make it without Government help, but at a much slower rate. Without Government enthusiasm and support for solar energy, there will be much less investor capital available.

Those companies owned by oil companies and the major semiconductor companies will survive. Small independents probably will not.

--The budget cuts should have no real effect on the industry's ability to compete in foreign markets. They will have no effect on us.

The industry can make it on its own, but a little political skid-greasing would help.

--The budget cuts will have little or no effect on the U.S. industry's performance in foreign markets.

--Currently, this firm is doing a small amount of PV R&D, but does not produce or market PV cells. If the Government pulls back, we may elect to get out of PV altogether, rather than move on into production, as the large volume customers are so limited--the Federal/state and local governments.

--It has been difficult for the DOE to get specific companies to commit to specific technology since the technology knowledge base is changing so rapidly. The companies are reluctant to invest their own funds in a particular technology and find it suddenly made obsolete. Therefore, the budget cuts will hurt and slow development of the industry because the Government has been carrying the risk of developing competing technologies. Without the Government carrying this risk, these technologies will develop very slowly in the private market.

--The budget cuts will retard the development of a marketable product both for the United States and abroad. The solar business is a high risk business requiring Government support for the present.

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16. Will the withdrawal of the U.S. Government from demonstration and commercialization slow the development and commercialization of solar energy in this country? in the world?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

The United States has not yet had a well understood commercialization program or plan. The Government should provide financial incentives to entice private capital to create the market. Government should not try to create the market on its own with its own purchases. Government should deal with imbalances in financial thinking in the private sector. For example, many manufacturing companies and industrial companies look at a 1 to 2 to 3 year payback for investment, whereas utilities think in terms of a 10 to 15 year payback period.

Anthony Adler

There is a need for some experimental demonstrations, but you do not need a large number of them. For instance, a one megawatt PV power plant constructed in a joint venture with a utility PV industry with 50/50 cost sharing would mean the Government might spend \$7-\$10 million while the utility industry would get necessary hands-on experience.

AMETEK, Inc.

If the budget cuts go too far into R&D, it will set back PV advancement and possibly the U.S. industry in certain technological development. For example, AMETEK has an unsolicited proposal before DOE involving a large sum of money to speed up the commercialization work and reduce the cost of PV cells to \$2.50 in 2 years. This request is not for basic research, but for application research (engineering development). If the proposal is not approved, AMETEK expects to be unable to meet the 1986 goal of 70 cents per peak watt.

The withdrawal of the Government support in PV development will slow the entry into the U.S. domestic market.

ARCO Solar Industries

On balance, the U.S. Government withdrawal will probably not slow development and commercialization of solar energy.

Dr. Karl W. Böer

The budget cuts could set the U.S. PV industry back 5-plus years in technological advancements and market penetration. The

## APPENDIX II

United States is sending the wrong signals concerning renewable energy. On the surface, it appears that the United States is deemphasizing renewable and encouraging nuclear energy. LDCs may follow this lead and do likewise. Another negative aspect is that it may cause a decrease in the number of students in colleges and universities entering solid state physics and related fields leading to semiconductor and PV work.

Furthermore, major industries may not be willing to carry the load of funding PV without continued Government support and market development to foster a large private market to generate adequate return on investment.

Frederick Schmid, President  
Crystal Systems, Inc.

The greatest threat to commercializing PV in the United States is the oil companies. We do not think that they have a real commitment to the PV industry. They are not really interested in showing that PV is a viable energy source. They are more interested in seeking profits wherever they are.

DSET Laboratories, Inc.

Answered in response to questions 1 and 2.

Exxon Enterprises

Withdrawal from supporting demonstration projects could slow development modestly.

Ford, Bacon & Davis Utah, Inc.

Most definitely, in both cases.

R. Douglas Wright, President  
Free Energy Systems, Inc.

The budget cuts will not affect this company one way or the other. It was not built on nor is it dependent on Government programs, projects or contracts. We deal strictly with the private market. We have found the DOE trade shows to be helpful, however, and would miss them.

If the current U.S. international solar energy programs were to be eliminated, the small businesses would be hurt more than the large companies because the large companies have their own international market connections. The small companies would lose further opportunities to stay alive since foreign sales are important if not critical. Without the international commercialization program, small companies' opportunities to enter foreign markets are limited.

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### Dr. Peter E. Glaser

Answered in question 1 and 2.

### John V. Goldsmith

With the termination of the commercialization program, PV technology should survive domestically due to the special market applications--remote locations, communications, agricultural and marine--that are already economically viable. The market will grow as the cost comes down relative to other energy sources. However, the number of companies left to develop this market and provide competition will be smaller as a result of the Government reductions.

Yes, in both the United States and the world, the withdrawal of official U.S. interest will slow development far more than will loss of funding. In other words, solar energy is now on the back burner. This move could reduce the technology's vitality as well as undermine its achievements.

### Lockheed Missiles and Space Company

No comment.

### Wesley G. Mathei, Manager Solar Products Division Microwave Associates, Inc.

Microwave's SERI funding will expire in May 1981 and may not be renewed. Our contract with Sandia Laboratories will expire at the end of 1981. If we do not continue to receive Government R&D funding we will continue at our own expense, but at a reduced level. Additional funds will probably not be made available from the company because the payback is so far in the future.

We do not think the cuts will affect or slow commercialization either in the United States or in the world. We do not see much value in the demonstration projects that DOE has done to date.

### Motorola, Inc. Semiconductor Group

See Question 1.

### Robert W. McGinnis Vice President and General Manager Photowatt International, Inc.

Yes, in both cases. Demonstrations are a positive influence. Customers that are buying PV now are the "rapid-innovators." They

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are sophisticated risk-takers and are able to see the advantages of the new system. To get to the rest of the customers, we need more demonstrations, reduced costs and time. The customer of the future will be the less-sophisticated, the less-technical-minded. They will need more time and exposure to accept new technology. We must plant the seeds in their minds now in order to have them as customers five years from now.

SES, Inc.

No comment.

SILTEC, Inc.

Absolutely. Withdrawal of U.S. Government support most likely will initially slow development in the world, but then other countries (Japan and West Germany in particular) will expand their development efforts and take over the market, eventually dominating the world market.

Spire Corporation

The Government withdrawal will slow development and commercialization of PV technology both in this country and the world. A lot of smaller companies will be hurt by the Government withdrawal. Many of these companies did their work by cost sharing with the Government. It will be very difficult for these companies to stay in business in the future unless they are associated with a large parent company with money.

Our R&D efforts were sponsored by DOE contracts, through Sandia Laboratories, JPL and SERI. These contracts have been for the development of production equipment and processes. Spire contributed about \$500,000 per year and the rest came from the Government.

Robert W. Willis, President  
Solenergy Corporation

Withdrawal from the demonstration projects is bad. We would like to see more small residential demonstration projects.

Dr. Milo Macha, President  
Sollos, Inc.

No comment.

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Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Our R&D efforts in concentrator collectors are being supported by DOE contracts through Sandia Laboratory. We will not be able to continue without these Government funds.

On the whole, commercial PV is not viable yet, and the withdrawal of Government support will slow the development of the industry and the technology.

Varian Associates, Inc.

No doubt it will. Some feel, however, that it might be a good thing because commercialization of PV has been premature and further research and development would allow superior long term solutions.

Westinghouse Electric Corporation

Westinghouse views photovoltaics as a high technology with many associated risks. Private companies will develop such a technology at a rate that is consistent with their opinion of their own product and their perception of the market. Government support in defraying the risk of developing such technology can accelerate the process. Withdrawal of Government support from the program will cause many companies to reassess their positions to determine how or if they will continue. At a minimum, we can expect the momentum to be slowed making it very unlikely that DOE cost goals will be achieved by 1986.

Other comments

--Definitely yes, it will slow it in both cases.

--Yes, to both questions. In the early 1970s, when our company had penetrated markets on its own effort with no established track record, it was very tough selling. Some demonstration projects at that time would have been a great help. Demonstrations convince customers to go ahead and buy.

--Withdrawal of the Government from commercialization and demonstration will slow development and commercialization of solar energy in the United States. Government funding of the riskier aspects of technology and market development broadens the market. We feel that the cuts will not affect our company because we are receiving sufficient funding from our parent company. In general, we see the market for the next 3 to 5 years as being overseas and do not believe the cuts will affect that market very much. However, cuts to the Solar Energy Bank or the tax incentives to purchasers of solar equipment could delay the commercialization in the United States even further than the 5 years it will take right

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now. The general public will not invest in solar equipment without low interest rate loans.

Cutting R&D will not effect us very much, either. We are latecomers to the market; other companies have benefited more from the DOE demonstration projects. These projects really have not driven the technology very much. DOE has been overly cautious in picking projects that will not fail and has tended to use off-the-shelf, out-dated technology. By not risking failures, DOE has failed to advance the state-of-the-art.

--The budget cuts may not adversely affect the industry too badly, because the funds were not being spent effectively in the first place. The AID PV projects are a good example; they have accomplished nothing for the U.S. PV industry. In these projects, NASA-Lewis is the interface, that is it buys the PV systems from U.S. companies, passes them on to AID who gives them to LDCs. The LDCs' contact is with AID, not with the U.S. company that built the system. The company has no entree to the country, no follow-on market is developed, the company can't service the hardware or hear the complaints of the user. AID simply puts it in and leaves. In other words, the U.S. Government is there in the middle of the market, or what would be the market, and should not be there. Its presence destroys normal market development; no distribution channels are developed. Some of these countries would have bought PV systems, but with AID on the scene, they wait to have them given to them. If the country cannot afford the system, but needs it, the U.S. Government can help by subsidizing the cost to the seller who can then reduce the price to what the country can afford. This would allow normal market channels to develop, and the LDC and the company to gain experience in dealing through them.

We are in favor of a change in the budget, especially in the way that AID spends its money.

--Withdrawal from demonstrations probably would slow commercialization somewhat. We have not been very impressed with the Government's commercialization efforts, and felt that the Government should not be in the commercialization business generally.

--The administration's position to eliminate Government support for commercialization is in line with this company's position that industry should push the technology into the market place. However, we believe that the Government should provide some level of domestic demonstrations and certainly should provide demonstrations overseas. Since U.S. companies face heavily subsidized competition, any demonstration exposure overseas helps U.S. companies develop their markets more rapidly.

The budget cuts will definitely set the solar thermal power generation technology back several years and it may not ever fully recover from the setback.

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17. How serious is the problem of access to capital? Is risk capital available to PV companies? Is Government capital (contract funds) important to the industry? to your company? Is it vital to the industry? to your company?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Access to capital is a problem, but Acurex could not attest to the degree. Risk capital is available, depending on the situation. If the deal is good, the capital is available. Acurex has obtained risk capital.

Government funding is important to both the industry and to Acurex, and in terms of R&D to prove system concepts in experimental technologies it is vital. Government capital should not be spent in pure demonstrations of proven technologies, particularly in repetitive demonstrations.

Anthony Adler

Risk capital is available. We have several investment deals underway at the present time and there are other financiers in the business. Solar Investors Associates was formed because its principals saw a need for capital in the solar industry. Muller and Company handles the public deals as well as some private deals. Solar Investors does mostly private deals and sometimes both Solar Investors and Muller and Company will jointly finance a deal. We try to get the right mix.

PV is a capital intensive industry. Right now there is about 10 megawatts production capability and about \$50 million of capital invested in installed equipment. In 1985, we see about 500 megawatts production and about \$2.5 billion of capital needed. Not all of that will be risk capital, since some will be for equipment leasing, etc. We predict that the small companies will grow faster and get larger because they are the risk takers and the innovators. The big companies do not take risks; they will try to buy out the small companies to obtain new technology rather than risk developing it themselves.

AMETEK, Inc.

AMETEK has provided all capital needs for solar development and production from its own resources and is not dependent on the Government for its requirements. A small company might not be able to generate its own capital or obtain it from private sources and could therefore be dependent on the Government. In any case, it is desirable that capital (regardless of source) flow to those

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areas of activity that offer the best opportunity for the development of viable and productive economic growth in companies which will, in turn, improve individual, industrial and national economic strength and well being.

### ARCO Solar Industries

Capital is a concern, but it is not an overriding problem. We believe there is ample evidence that the capital market supports high technology ventures.

### Dr. Karl W. Böer

NO comment.

### Frederick Schmid, President Crystal Systems, Inc.

We developed our PV technology largely with Government funds, having received about \$2.5 million from DOE's Jet Propulsion Laboratory since 1975. We are now seeking private capital to construct a prototype production facility to enter the commercial market. We could never have raised private risk capital to develop our technology; it was available only through the Government programs.

The Government cost sharing approach has been good. We are concerned, however, about funds given to a certain PV company without it being required to disclose the technology or information it develops with these funds. The contract requires the company to disclose the information only if it feels that it is not proprietary. These funds are being used for commercialization of a product, not development.

Some risk capital is available to PV companies, but it is becoming more and more difficult to find as the Government pull-out becomes more widely known. The PV business is still a high risk undertaking, and the withdrawal of Government support and interest makes it seem even more so.

### DSET Laboratories, Inc.

1. Access to capital is very serious, especially for small companies.
2. Cannot comment.
3. Government capital in the form of R&D and market development funds is important to the industry; however, Government as a user market is more important in the short term.

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4. Government funds are important to DSET to help initially amortize costly test facilities that are required to meet the needs of a growing industry.
5. As such, Government funds are vital to both the industry and to DSET.

### Exxon Enterprises

To date, private capital has been available to the PV industry. We expect that this will continue to be the case if there is the expectation of earning a reasonable return on investment capital.

### Ford, Bacon & Davis Utah, Inc.

1. Access to capital at reasonable interest rates is critical.
2. Generally speaking, risk capital is not available to PV companies.
3. Government funds are very important to the industry.
4. Government funds are important to Ford, Bacon & Davis. However, we also do work in the private sector.
5. Government funds are vital to the PV industry, but not vital to Ford, Bacon & Davis. We could switch to the private sector.

### R. Douglas Wright, President Free Energy Systems, Inc.

Access to capital is not too serious a problem if you are willing to pay the high interest rates.

### Dr. Peter E. Glaser

PV companies need capital because of the long range technology development requirement. Small companies are able to be innovative, but the need for capital and management will drive them to join with large companies. Risk capital is available to qualified companies.

### John V. Goldsmith

1. Access to capital is very serious, the problem is no different from many other developing industries.
2. Yes, risk capital is available to PV companies if they have something worthwhile to sell.

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3. Yes, Government capital is important to the industry.

4. Yes, Government capital is important to Solarex in the long range research and development activities. Lack of a strong posture by Government in this area will temper greatly our own long range investment.

5. Government capital is vital to the PV industry for work directed toward near-term, very low cost technology. It is not vital for commercial development.

6. Government capital is not vital to Solarex for commercial development. One should not confuse commercial growth of industry with the U.S. need for alternate energy sources. The technology will grow commercially on its own merit, but will take much longer than if Government accelerates the process. The development of an alternate energy technology compatible with U.S. national needs will take stimulation from the Government - otherwise, it will take a long time to develop.

Lockheed Missiles and Space Company

No comment.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

Our company is developing a concentrator cell. Over the past three years, our total PV R&D expenditure has been between \$500,000 and \$600,000. Of this amount, about \$400,000 was Government funds through R&D contracts and the rest was corporate funds.

Microwave Associates has access to capital from its parent corporation MACOM. MACOM does see this as a high risk business and the question of timing is critical. We are not projecting large sales for at least 5 years from now, and that is a long time to wait for a return on investment. If we do not continue to receive Government funding, we will continue the development program, but at a much reduced rate which will delay the market entry date accordingly.

Motorola, Inc.  
Semiconductor Group

1. Access to capital is very important.
2. Risk capital is not available to PV companies.
3. Government capital is important to the industry in R&D.
4. Government funds are important to Motorola in R&D.
5. Government funds are not vital to the industry or to Motorola.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

1. Access to capital is very serious. The PV industry needs external capital, since at the current profit levels it is difficult to generate internal capital.
2. No comment on risk capital.
3. Government R&D funds are essential. The original Government purchases of PV were the single largest incentive in accelerating the industry. It made the industry what it is today. The Program Research and Development Announcements (PRDA) approach stinks! It was a nice idea, but was poorly implemented--only two companies got all the business.

SES, Inc.

Risk capital for entering an uncertain market such as photovoltaics is difficult to obtain. Companies which are interested in the PV business generally are high-technology, long-term (greater than 10-year) planners, and high risk takers.

SILTEC, Inc.

1. Access to capital is always a problem. Capital requirements are high for setting up a PV manufacturing facility.
2. Some risk capital is available to the industry, but more technology development is needed before a significant market can be created.
3. Government funds are critical to the industry.
4. Government funds are mandatory if SILTEC is to continue PV technology development.
5. Government funds are absolutely vital to the industry in the form of funding for technology development.
6. SILTEC will not be able to compete in the PV market without continuation of Government funding. Up to now, all of its solar PV business has been Government R&D work. Last year, SILTEC spent \$1.7 million on commercial non-PV related R&D plus about \$540,000 on Government financed PV R&D--\$470,000 by the Jet Propulsion Laboratory and \$70,000 by SERI. Although only about one percent of SILTEC's total business activity was from Government R&D work last year, the proposed budget has now completely

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killed this business. When it was announced, SILTEC was one day away from signing a new contract with JPL and had bid on another. JPL immediately cancelled both Requests for Proposal. SILTEC's JPL contracts are now completed and we have no more Government work. SILTEC has just completed development for commercial sales of a new microprocessor-controlled Silicon Crystal Growing Furnace which would be adaptable to the PV Technology Development program. This equipment is the best available anywhere, but since it was just announced in April 1981, the current sales volume is low.

### Spire Corporation

Capital is a very serious problem. We have tried all kinds of avenues and capital is just very hard to get. One reason may be that the PV industry does not have an established track record. Investors see it as very risky. We have spent a lot of time trying to raise capital, and have not been very successful. We did obtain \$250,000 from the Massachusetts Technology Development Fund.

### Robert W. Willis, President Solenergy Corporation

Risk capital for PV companies is not available anywhere. Although a recent newspaper article cited a venture capitalist as looking for new areas to invest in, it was just all talk. Part of the problem is that many people do not believe PV will work. If they think it will work, they do not understand how a small company can survive competing with companies tied to big oil companies.

I have talked to various people to raise capital. Most venture capital investors said I must be out of my mind.

The original capital with which I formed this company was partly mine, partly an investment by another company, and some funding from the Massachusetts Technology Development Corporation, which supplies money to high-technology, high-risk businesses.

We also plan to obtain Government R&D contracts and have recently taken on a new employee to help in this effort.

### Dr. Milo Macha, President Sollos, Inc.

1. Access to capital is very serious; one of the major problems of the industry.
2. Risk capital is very difficult to obtain, especially for small companies like Sollos.

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3. Government funding is very important to the industry and to Sollos, but needs to be better managed.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Our company got started in solar energy with funding from an AID project in Senegal and \$600,000 of our own funds, which represented about 10 percent of the company's 1979 net profits. (The company existed before then, but was not in the PV business.) We are now developing a concentrating PV collector for the commercial market. It is still about a year or two away from being market ready, and we will not be able to complete development work without Government funds.

Concerning the industry as a whole, capital will become available when the market develops. The flat plate collector market now exists for small, remote power systems, but concentrator collectors are aimed at a different market. Concentrating PV collectors are lower in cost than flat plate collectors and the concentrator offers heat as well as electricity.

Varian Associates, Inc.

1. Access to capital is very serious. It is a major problem in the industry today.
2. Not much risk capital is available to the PV industry.
3. Government funds are very important to the PV industry.
4. Government funds are very important to Varian. Without them, we would not be in the PV business.
5. Government funds are vital to the industry.
6. Government funds are vital to Varian. Not necessarily vital to the company remaining in business, but vital to remaining in the PV business.

Westinghouse Electric Corporation

Risk capital is vital to the industry, but it is becoming more scarce, partly because of the administration's budget cuts. This will, no doubt, adversely affect recent and anticipated technology developments and breakthroughs.

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### Other comments

--Access to capital is a very serious problem for small companies and independent companies. Oil companies and solar companies owned by major semiconductor companies do not have much of a capital problem.

A year ago, risk capital was available. As of right now, it is not, primarily because of reaction to the Government's proposed budget cuts and the withdrawal of Government assistance from the industry.

Obviously Government funds are important to the industry.

Government funds are important to this company.

Government funds are vital to the industry if it is to grow rapidly. They are not vital for the industry to merely survive and grow at a much reduced rate with a much lower profile.

Government funds are not vital for this company's survival. It is important for rapid growth. Right now, the Government pull-back has been having a drastic braking effect upon the entire industry. In other words, the potential damage of the budget cut-back is not merely potential--it has already started to take place.

Capital is the name of the game. It is necessary.

A surprising amount of risk capital is available. Anyone with an idea can find capital and they do not even have to have a good idea.

Government R&D funds are vital to the industry.

Government funds are important to our company--not vital, but important.

--We can obtain risk capital from our parent corporation. Funding things like PV R&D is a natural for an oil company because they are used to funding long range projects with high potential.

--(GAO comment: This small company was recently saved from bankruptcy by being purchased by another company. It has never received any Government funding, although it had bid on several DOE demonstration projects.)

--It is a problem. Venture capital has dried up. Part of the problem is that oil companies are tending to monopolize the industry, both nationally and internationally.

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18. If Government assistance is still needed, what form should that assistance take and why is it needed?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Answered in previous questions. Assistance is still needed. Government assistance to stimulate solar energy in a PV market can be done and will have a very high return.

Anthony Adler

Answered in other questions.

AMETEK, Inc.

The establishment of Federal and state tax credits were of major importance in the development of the residential solar thermal market and industry. Tax credits of equivalent amounts are not provided to the commercial or industrial sector and therefore solar industry growth in these areas has been inhibited.

Tax credits could be of equal benefit to the PV industry, however, since the initial market will not be residential, but rather, stand-alone applications, extension of the tax credit to the commercial and industrial sector will be required.

ARCO Solar Industries

The DOE PV program has been positive in the past, but if continued is likely to be increasingly counterproductive in a number of ways, as follows:

1. The often-stated DOE price reduction goals of 70 cents per peak watt by 1986 and so forth serve as a disincentive to immediate sales. In other words, some potential customers hesitate to buy a PV system now if it will cost much less in a few years, even though it may already be economic.
2. DOE representatives have offered to give away free demonstration PV systems to LDC governments. LDC governments think they have been offered free systems. When private sales representatives appear, they refer to these expected gifts and have told the salesman to return after they have evaluated the free demo system.
3. The U.S. demonstration projects have focused on very expensive, state-of-the-art systems; systems that are maybe 10 years away from commercial reality. These do not serve to create a market in the eyes of foreigners or potential U.S. buyers

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observing these projects. It reinforces in their minds that PV is indeed an energy form of the future, not of the present.

Furthermore, LDC governments tend to relate closer to other governments than to private companies, and LDC governments tend to believe U.S. Government statements about when PV will become economically viable and that it will cost only 70 cents per peak watt by 1986.

Why isn't AID more helpful on PV projects? A number of LDC governments have also raised this question with us.

ARCO views the PV market as being in two phases, (1) a long-term market which depends upon breakthrough technology R&D for future growth, and (2) an immediate market for current technology.

Tremors from Washington are causing many marketing problems overseas. Europeans especially are concerned that Washington will redebate the technical feasibility of PV and scare the customers away again.

Our thoughts as to what form U.S. Government assistance should take can be summarized as follows:

Take R&D away from the DOE and put it under the National Science Foundation (NSF). The DOE approach to R&D by doing much of it through large company contractors is counterproductive. We do not see timely feedback as to what the results of DOE contractor-performed R&D projects are. If something does not work, nothing is ever heard of it; if it does work, the large company contractors hold it for competitive advantage. Both negative feedback (what did not work) and positive feedback (what did work and how) are needed in order to minimize wasted effort (NSF has greater flexibility to change direction and examine new approaches). DOE has a tendency to hold onto aspects of programs long after they have become counterproductive.

Dr. Karl W. Böer

Government assistance is needed in establishing technology credibility. The Government should offer financing and demonstration of PV systems in foreign countries' metropolitan vicinities (where many people can see them) to show its application possibilities. Government funding is also needed in material research to look for substitution and cheaper ways of producing PV cells. The government also needs to educate the public on PV technology as well as its cost competitiveness in the current market place. R&D is also needed on PV theory and electric modeling.

Frederick Schmid, President  
Crystal Systems, Inc.

The U.S. is putting all its eggs into one basket by using semiconductor grade silicon for its PV material. Crystal Systems is experimenting with using less refined metallurgical grade silicon for making PV cells. Because of the impurities in the silicon, the electrical reaction produced is less efficient, but the cost of the basic material is much less also. By way of illustration:

	<u>Cost of silicon</u>	<u>Efficiency of cell</u>
Semiconductor grade	\$65/kg	15%
Metallurgical grade	\$1.50/kg	7%

The industry needs the Government's help to develop the technology to the point of commercial viability. The immediate need for Government help is now in getting the cost of the raw material down. This will make the PV industry grow. Growth will be through small individual companies.

DSET Laboratories, Inc.

Answered in previous questions.

Exxon Enterprises

See answer to question 3.

Ford, Bacon & Davis Utah, Inc.

See response to question 3.

R. Douglas Wright, President  
Free Energy Systems, Inc.

The Government should support small PV companies to make sure that they stay in the market and offer stronger competition against larger companies. Not only is competition important, but so is the labor force and jobs. Small businesses provide 60 percent of all U.S. employment and 80 to 90 percent of the creation of new jobs. Consequently, the Government should be letting contracts to small companies to test their PV technological advancements as well as those of the larger companies.

We should not look to PV as the only solar technology for solving energy problems. There will be various applications in which PV and solar thermal or wind turbines can complement each other, especially overseas where energy grids are not established.

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The best thing the Government could do for the PV industry would be to fund demonstration projects around the United States and overseas in places where millions of people can see them every day. Seeing the technology actually working would do more to educate and inform the people than the present approach of placing demonstration projects in out of the way places for a few selected observers.

Government support should also be in (1) R&D, (2) demonstrations and (3) proportional distribution of PV R&D and demonstration contracts divided between small and large companies.

### Dr. Peter E. Glaser

Government assistance is needed for R&D, investment in new production technology, and loans to prospective purchasers in foreign markets. One important area that is being overlooked is the potential for use of PV in space. Currently the major PV market is the terrestrial market. By 2000, the space PV market could be larger than the terrestrial market because power will be needed for the defense of space as well as for its industrial exploitation.

In PV market development, the most important thing for the Government to do is to plan jointly with the PV industry. Many of the PV industry's problems are not unique to it. Effective Government efforts are sometimes frustrated because Government agencies cannot work together, let alone work with industry. If the Government does not plan with industry to market overseas, the PV industry could be in the same situation as the U.S. automobile industry, and lose not only its share of the world market, but also its domestic market.

### John V. Goldsmith

It depends on the Government's objectives. Does the Government want rapid, large-scale utilization of a non-petroleum energy source or does it want strictly commercial development? Assuming the former, then there is a need for a balanced program that includes marketpull, technological innovations, infrastructure development, electric grid interface, etc., - a total system approach to produce hardware.

### Wesley G. Mathei, Manager Solar Products Division Microwave Associates, Inc.

The Government should fund R&D and help commercialize the product. The key is to increase the efficiency of the basic PV cell.

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The Government role could be similar to that it played in developing the semiconductor industry. At the time that Bell Laboratories first came up with the idea of the transistor based upon semiconductor materials, the price of silicon was very high. As the market expanded, the price came down. It was the initiative of the U.S. Government that created the semiconductor industry at that time. Bell would have put the idea on the back shelf because it was not economic at that time. The Government's involvement accelerated the development of the industry and all the benefits it has brought by about 10 years.

The Government should continue to study silicon cells in its R&D to try to increase the conversion efficiency to 20 percent or more. R&D should also proceed on gallium arsenide as a PV material. Right now, it costs 4 to 5 time more than does silicon because the sales are small and the need is not there.

DOE must choose which technologies appear the most promising. It cannot afford to continue funding 16 different areas of R&D. It should narrow the field down to the most promising 5 or 6 and go with them. This will not happen though, because Government people don't like to make decisions. DOE will not eliminate programs, but will just apply a 10 percent cut across the board. The top management level in DOE will decide on a political basis which programs will continue to receive full funding and the rest will take a percentage cut.

Government R&D should concentrate on the initial or early stages of research. This is the stage that is difficult for companies to muster the funds for. As the technology nears the point of commercial viability, the companies should take over and the Government should move out. Another reason that the Government role should be in basic R&D, the front end, is because if it screws things up there the long range effect is not so bad. If the Government gets involved at the point of commercialization and screws things up it might affect the market itself and have much longer adverse effects.

### Motorola, Inc. Semiconductor Group

The Government needs to decide just how important is it to accelerate development of the PV market, and then proceed consistently toward that goal. Cutting the solar budget will delay PV market and technology development, which, in turn, will have two major ill effects; (1) it will delay the arrival of U.S. energy independence, and (2) it may remove U.S. companies from foreign PV markets.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

The Government role should be in R&D, demonstrations, and trade stimulation via trade shows. It will be a giant mistake to cut out everything except basic research. The real growth will come from the results of technology development, not basic research.

SES, Inc.

We believe the Government PV program has been focused on the wrong end of the technology. It should be putting funds into PV fundamentals that have the highest risk and not into production methods. Consequently, if the budget cuts go through, we are not sure what the effects will be on the industry as a whole.

SES is attempting to be able to make PV panels which can compete if prices achieve the DOE goals. A lot has to be accomplished before then; i.e., continued financial support, successful research, resolution of development and production problems. The last step in achieving a very low cost PV cell offers the strongest challenge and biggest obstacle that may cause goals to slip in time.

The Domestic Policy Review of Solar Energy reported that by the year 2000, 18 to 20 quads 1/ of energy could be supplied by solar energy. Of this total, 1 quad is to be supplied by PV if substantial cost reductions are achieved. SES believes the estimates and projections are overly optimistic and are unrealistic. For example, 1 quad of electricity translates roughly into over 300,000 megawatts per year. Currently, the United States has a production capacity under 6 megawatts. To achieve the 1 quad figure, given that PV cells are cost effective, significant amounts of investment and other activities (building plants, materials, locating and developing material resources, testing, developing markets) has to occur. Consequently, achieving the year 2000 goal of PV supplying 1 quad appears unlikely, due to the massive amounts of capital needed and the time required to put the product in place.

This brings up another interesting point. Because of the billions of dollars that must be spent to tap the U.S. market and the European and LDC markets, it is doubtful that a single company or few companies will be able to invest such large amounts of capital. There is room for all interested parties.

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1/A quad is one quadrillion British Thermal Units (BTU) of energy.

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The Government should not be involved in subsidizing the commercialization of PV. SES agrees with the administration that DOE should support the high risk areas of PV development.

### SILTEC, Inc.

Government assistance is still needed in technology development and advanced research and development in order to reduce cost per peak watt so that PV will be cost competitive.

### Spire Corporation

It is important that the Government continue to fund R&D efforts. The loss of Government R&D funds would be catastrophic to the industry. It is especially vital to the small innovative companies. The large companies are basically not risk-takers; they are mainly interested in producing cells and making a profit selling current technology. This attitude tends to freeze the technology. However, it is largely the small companies that are working on new technology and new processes, such as Crystal Systems growing square ingots, other small companies working on ribbon technology and thin film technologies.

### Robert W. Willis, President Solenergy Corporation

Making Small Business Administration loans available for small PV companies to get started and keep going would help. It is also important to have a small business set-aside provision in DOE's programs in order to give small businesses part of the action and support.

### Dr. Milo Macha, President Sollos, Inc.

The Government should finance R&D in innovation and not in redundant duplication of the same technologies. The key to developing the PV industry to the point of commercial takeoff is reduction of material costs, and eventually overcoming nontechnical barriers to commercialization, such as building codes, union rules, etc.

### Ronald S. Scharlack, Manager Solar Systems Thermo Electron Corporation

The Government should assist in technology development, but proportionately less of the R&D funds should be spent on flat plate PV, since it has received most of past R&D funds. We do not think the Government is spending its money in the best areas.

The oil companies are not serious about getting results from their PV investments; it is mainly for public relations. When you

look closely at how these companies are spending their money, you see that a lot more could be done with a lot less cost. Their expenditures mainly provide public relations and serve to keep them in a strong marketing position.

Varian Associates, Inc.

The Government's help is very important in the early stages of research. The Government, however, should also attempt to achieve better balance between competing technologies in funding research efforts. So far, most DOE R&D money has gone into silicon technologies and very little into gallium arsenide which we feel is a more promising technology. The Government should put money into developing manufacturing techniques for the technologies developed in R&D. In terms of development and perhaps even commercialization, perhaps a Federal program of subsidizing the cost differential between PV and alternative energy forms would be good. Such a program could then gradually taper off to nothing as PV becomes cost competitive with other energy forms.

A great danger that the budget cuts could bring, is that in allocating a severely reduced budget, DOE would be running a great risk of prematurely selecting a particular technology to fund and dropping others. That is, if DOE had the choice between reducing all programs evenly and not being able to fund any of them effectively, and the alternative of eliminating some programs in favor of concentrating funds on the remaining programs, the latter choice would run the risk of selecting a technology that, given equal development, may prove inferior to the others.

Westinghouse Electric Corporation

The PV industry needs continued Government support in high risk areas of R&D and engineering production design. In selecting high risk areas, the Government should listen to the industry.

Other comments

--The Government's role should be to fund basic research and PV cell manufacturers until such time as the commercial market has developed. Demonstration projects are useful and important, but the Government, DOE particularly, has spent far too much money on duplicative projects. In this sense, the demonstration projects have been a waste of time and money. One or two projects are sufficient to demonstrate the technology; there is no point in repeating the demonstrations.

Continuity is a big problem in working with DOE. Key personnel change too frequently. DOE is very inefficient, almost ineffective, in its contracting procedures.

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--Government assistance is needed in research and development, demonstration projects, and in developing and generating market pull in foreign countries. The United States is not likely to develop a PV market in Europe or Japan, but the Europeans and the Japanese will very likely develop a PV market in the United States. Government assistance is needed to keep the momentum that we have built up through the past several years and through investments of hundreds of millions of Government dollars in order to prevent losing the foreign market completely to the European and Japanese companies, and losing a good percentage of the domestic market as well.

--Assistance is needed in R&D, feasibility demonstrations, and in market development through incentives.

--The Government should fund R&D. For example, our company has some good research ideas on the shelf which have time frames too long for corporate funding. There should be Government funding to increase the fundamental understanding of PV cell efficiency.

--The industry has received mixed blessings from DOE's involvement in the international PV area. For example, NASA-Lewis' involvement in international activities has gummed up exports by providing PV demonstrations in AID countries.

Instead, the Government should be stimulating trade through exhibitions and trade shows for industry participation. Using this approach would bring the right people together to discuss sales, joint ventures, etc. DOE's international commercialization efforts have been successful in achieving international solar trade objectives. This program, however, will be terminated by the budget cuts.

U.S. companies should be permitted to work together in foreign markets in order to more effectively compete with the government-supported and led companies of France, Germany and Japan. U.S. anti-trust laws prohibit this. The French Government almost forced the consolidation of 3 French companies by stating that it would support only one PV company. What resulted would be the equivalent of getting Exxon, General Electric and Texas Instruments together. Two of the companies were Compagnie Generale d' Electricite (CGE) and RTC Phillips. They and another company formed Photowatt International. [GAO note: CGE and Societe Nationale Elf Aquitane formed Societe Francaise des Photopiles which works with Photowatt International, a CGE subsidiary. RTC later joined the association. See Appendices I and IV for a more complete discussion.] The Germans are doing something similar in getting two big companies to form one team. The Japanese Government's MITI office is also forming a team of strong companies.

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--In general, DOE should (1) emphasize and fund R&D, but should go about it in a different way than it does now. R&D should be done by teams formed from academic experts linked with product-oriented companies, in order to produce research that would have a direct bearing upon producable technology. This is vital in order to have some short term results. On the other hand, there should always be some long term advanced R&D worth doing. (2) DOE should fund some demonstration projects, but in doing so it should attempt to involve more than one company and weight competitive awards in favor of a large number of medium and small company teams in order to get the interest of most companies and thereby help build the industry. Also, this would help get the benefits and new ideas from competition and the high quality that should result from this involvement. The Government should not go into a big buying program to push down cost.

Companies that limit their business should not get Government funds, by this we mean companies that are just in the contract game and have no lasting commitment to the PV industry--companies that have no intention of becoming PV cell manufacturers, but have engaged in research in order to keep their people busy and because Government money was available. We also feel that foreign owned companies and others that send the technology overseas should not receive DOE R&D funds.

To develop foreign markets the Government needs to do demonstrations of total systems in foreign countries using different company teams, not giving all the contracts to the same company.

In summary, the budget reduction would undoubtedly slow development of the U.S. PV industry. The Congress should take a close look at how the budget cutback is put into effect. We do not want to chop the tree down, just prune it. R&D funds have been spent in a somewhat inefficient manner up to this point; these funds should go to companies that have a commitment to the industry, and will probably stay in it.

Government funds should not go to companies that have access to other capital, such as the major oil companies that have bought into the PV industry.

Foreign-owned companies which manufacture abroad using U.S. funded technology should not receive U.S. R&D funds.

--The Government should provide a demonstration program to develop user confidence in solar energy as an alternate energy source. Current users will not apply their funds for this purpose until feasibility of solar energy is shown.

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19. Will the PV industry ever reach the "take off" point where no Federal assistance is needed? When and how will that point be reached?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Yes, it definitely will reach that point. We cannot say in terms of when as a point of time, but it will be reached when the cost benefit of PV becomes viable with the alternatives. Some PV technologies may become independent of the need for Federal funds sooner than others. In other words, sometime after the PV industry is commercially viable, the Government may still wish to fund R&D in improvements for other forms of the technology.

Anthony Adler

The domestic market should be viable by 1985. Even after then, however, there will still be a need for a small amount of "blue sky" PV R&D work by the Government.

AMETEK, Inc.

It is difficult to say when the industry will not need assistance from the Government. It depends on a number of technological break-throughs required in production and material substitution. Also, technically sound PV systems have a market right now in many foreign countries.

ARCO Solar Industries

Yes, it is fairly close right now.

Dr. Karl W. Böer

Large scale residential use of PV systems will probably start around the year 1990 with continued Government support. Without this support, a 10-year delay is probable.

Frederick Schmid, President  
Crystal Systems, Inc.

No comment.

DSET Laboratories, Inc.

Yes, it will. It is not there yet. The single most important Government program to accelerate the normal rate of PV market development is the current Low Cost PV Program of the Jet Propulsion Laboratory. When and how the take-off point will be reached

is entirely up to the cooperative stance between U.S. Government and U.S. industry.

Exxon Enterprises

With the exception of long-term basic R&D and educational efforts, Federal assistance is not needed. A large market will not develop until photovoltaics becomes cost-competitive with other alternatives in a much broader set of applications than is currently the case. It is difficult to tell when this might be, but probably later than 1990.

Ford, Bacon & Davis Utah, Inc.

Yes, when the price reaches about \$1.00 to \$2.00 per peak watt. To get the price down, mass production is needed. To get the mass production, a market is needed. To get a market, \$1.00 to \$2.00 per peak watt is needed. This "chicken and egg" cycle is faced by most new industry in the early stage. New process and concept development usually takes 10 to 15 years. There are certain applications today where PV can be considered a viable solution at present prices. However, the market is not large enough to support a strong competitive industry.

R. Douglas Wright, President  
Free Energy Systems, Inc.

It is hard to say when the PV industry will reach the take-off point if one is considering common everyday residential use. Without that stipulation, it is here right now, because PV has its place of commercial viability where fuel costs are too high, i.e., remote areas, marine applications, etc.

Dr. Peter E. Glaser

No comment on take-off point for independence from Government support. The market will determine prices, not the DOE goals. PV technology will not meet DOE goals without continuing R&D support. Even with lower cost and higher efficiency, new PV technology will be needed to get the price down to levels which will compete in foreign markets.

John V. Goldsmith

The photovoltaics industry has "taken off" commercially. However, growth as an alternative energy technology depends on the U.S. Government. The DOE cost goals are not achievable under the new Government approach. Private capital will not flow into PV investment rapidly enough.

Lockheed Missiles and Space Company

No comment.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

The industry should take off in 5 years, unless there are budget cuts which could drag it out to 10 years.

Motorola, Inc.  
Semiconductor Group

It is already at the point of independent viability. It is now just a question of how fast do we want the market to grow. Without Government assistance, PV is economically competitive in certain remote domestic and in many foreign locations. The market can grow from this base. The rate of growth will depend upon the rate of R&D to reduce cost and increase conversion efficiency. However, if the Government wants PV to contribute to reducing U.S. dependency on imported oil in a significant fashion within the next 10 to 20 years, it will have to intervene in the normal market development and accelerate its normal growth through accelerated R&D and accelerated market penetration.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

Absolutely. Its just a question of time. The point will be reached when the peak watt cost reaches \$2.00--at that point the industry will take off like a sky-rocket.

SES, Inc.

SES is hoping that PV will take off in due time. This is not to say, though, that the Government should discontinue funding all technological R&D.

SILTEC, Inc.

Yes, it will. It will be reached when further development is accomplished to improve cell efficiencies and lower the cost of materials to obtain a PV power cost of about \$2.60 per peak watt by 1986.

Spire Corporation

The take off point will be reached when we get close to establishing a domestic market, which should take place in about 5

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years. The need for Federal assistance should terminate by 1990. Product cost is the key for opening a domestic market.

Robert W. Willis, President  
Solenergy Corporation

No comment.

Dr. Milo Macha, President  
Sollos, Inc.

No comment.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Concentrator PV systems could reach the take off point by 1986. Production will start a couple years before that, but field tests will be required after production starts. The costs should drop considerably after that. Thin film technologies will not make it for another 20 years. Note that the estimate of concentrator systems making it by 1986 assumes continuous development funding until then. If funding is interrupted, the development time will stretch out accordingly.

Varian Associates, Inc.

Yes, it will. When and how depends on the volume of production and sales and the economies of scale. It also depends upon the point at which the descending PV cost curve intersects with the rising cost curves of other energy forms. This will occur probably in the next decade.

Westinghouse Electric Corporation

The photovoltaic industry will "take off" when the cost of energy provided by a photovoltaic system is comparable to that of other power sources. This is projected to occur when the DOE cost goals are achieved.

Other comments

--With the present technology, no it will not. With a technical breakthrough to reduce the cost, yes, it definitely will; although it appears as though these technical breakthroughs are close. The market for remote applications of PV is viable without Government funding right now, and will continue to be so.

--It will reach that point when private investors will provide most of the capital because they expect a good return. However, the Government will continue to have long-term interests and

needs as it does in the nuclear and the semiconductor industries. The semiconductor industry was also developed with Government R&D funds and the Government was the sole customer of the products for a long period of time. This industry is now a large industry financed largely with private capital, yet the Government continues to have R&D needs which are met with its own funds.

--PV will take off when its costs get below that of alternative energy sources. We believe that the DOE cost goals are meaningless and even counter productive. The market will determine the prices, non arbitrary goals.

--Yes, when user acceptance and economic viability are met. When the price of solar energy is competitive with other sources.

20. Will the deregulation of oil and gas prices help the PV industry? How?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Yes, by raising the prices of oil and gas to their real level.

Anthony Adler

Yes. It will allow PV to compete closer to the margin rather than at low average subsidized prices.

AMETEK, Inc.

Any long term increase in the cost of fossil fuel will make a PV device more economically competitive and should help the industry. The deregulation of gas and oil may or may not have this effect over the longer term.

ARCO Solar Industries

Absolutely. The equivalency of energy prices will even the competition.

Dr. Karl W. Böer

No comment.

Frederick Schmid, President  
Crystal Systems, Inc.

No comment.

DSET Laboratories, Inc.

Yes, definitely. By making PV competitive with traditional energy sources.

Exxon Enterprises

Deregulation will make PV more competitive because the real cost of energy sources will be used in making economic comparisons. Even with deregulation, however, large markets for PV will not materialize until the costs of PV systems are reduced considerably.

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Ford, Bacon & Davis Utah, Inc.

There are two sides to the deregulation of oil and gas prices. On the one hand, deregulation will show that oil refiners have the capacity to meet demand. The price will soften for from 4 to 5 years. This will curb interest in alternative energy for that period and thus also reduce the interest in the money going into PV development. On the other hand, oil companies will make profit which will go back into exploration of oil and they will find more oil. With these profits, they will also continue to spend on alternative energy sources, such as photovoltaics. In order to be ready for the future, this will help the PV industry. It remains that the main sources of dollars invested in PV are the U.S. Government and the major large companies like the oil companies which can afford to carry a development over several years without an immediate (1 to 2 year) return on investment.

R. Douglas Wright, President  
Free Energy Systems, Inc.

Deregulation of oil and gas prices is the best thing that could happen to the PV industry. This action will assist in introducing the technology into the market place earlier.

Dr. Peter E. Glaser

No comment.

John V. Goldsmith

Any action that allows energy costs to be fairly measured will help the PV industry. PV technology will be able to penetrate the diesel generation remote power market--which is the next major target.

Lockheed Missiles and Space Company

No comment.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

Deregulation will help the PV industry. Pricing oil and gas at their real price will help attract more interest to alternative energy sources.

Motorola, Inc.  
Semiconductor Group

Yes. The higher are oil and gas prices, the more competitive PV is to the average consumer.

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Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

Yes, as the cost of heating and cooling with oil and gas goes up, alternatives will become more attractive. For example, last year Brown University's heating and cooling bill exceeded the cost of its faculty salaries.

SES, Inc.

No comment.

SILTEC, Inc.

Yes. Oil prices will not be artificially depressed, and with deregulation, oil prices will rise to the level where PV technology becomes more competitive.

Spire Corporation

Deregulation will make PV more competitive with other energy sources.

Robert W. Willis, President  
Solenergy Corporation

Anything that increases the price of other energy sources will help the PV industry.

Dr. Milo Macha, President  
Sollos, Inc.

No comment.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Deregulation will help by raising the price of oil and gas to its true value relative to other energy sources. The full incremental cost of adding more energy should be considered. If a plant generating its power by hydro required more power and had to obtain it from a coal plant, the power consumed would be costed by an overall average of producing power both by hydro and coal. In other words, the high incremental cost is buried or hidden by averaging it in with the lower cost original power. It would be better to isolate the cost of the incremental power from the new plant and thus show the full cost of new power today.

Varian Associates, Inc.

Yes. While many PV markets will develop, the big one will be with respect to public utility power grids. The higher oil and gas prices are, the sooner PV will be competitive in the commercial market.

Westinghouse Electric Corporation

Deregulation of oil and gas prices both helps and hurts the PV industry. The favorable side is that the price at which PV becomes competitive is higher. The bad side is that the other components of the PV system (other than the cell itself) are going up in price due to a direct relationship of costs to energy prices.

Other comments

--Yes, obviously. The higher the cost of oil and gas, the closer to economic viability will be photovoltaics.

--Yes, of course. There will be more applications in which solar will be competitive.

--Deregulation will improve the economic situation for PV. This is a step in the right direction.

--Yes, this will increase the price of competitive sources to true market values.

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21. Should the Government subsidize and assist any form of energy development and commercialization?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

Yes, it should do so any time that the national interest cannot wait for the normal market price development.

Anthony Adler

Yes. The overriding factors are energy independence and national security, along with rational and planned impacts on the economy.

AMETEK, Inc.

No comment.

ARCO Solar Industries

Yes, the Government should undertake R&D and demonstrations in energy technologies that are too risky for the private sector, but leave marketing and commercialization to the private sector.

Dr. Karl W. Böer

No comment.

Crystal Systems, Inc.

No comment.

DSET Laboratories, Inc.

No comment.

Exxon Enterprises

The best approach would be to have no subsidies for any energy sources such that the marketplace determines the balance among competing fuels. To the extent that subsidies do exist for other fuels, however, consistent incentives should also be provided to solar.

Ford, Bacon & Davis Utah, Inc.

Yes, only until the development phase can survive on its own in the market place. Care should be taken to see that projects are assisted that have good potential to survive on their own.

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Government should also provide enough safeguards for its investment that the same mistakes are not repeated as were made in the nuclear industries where extensive Government support was essentially wasted by allowing pressure groups to dictate legislation which was not in the best interest of the public.

R. Douglas Wright, President  
Free Energy Systems, Inc.

No comment.

Dr. Peter E. Glaser

No comment.

John V. Goldsmith

The past U.S. photovoltaics plan was well founded because the need for alternative sources was obvious. The present administration is confusing this issue.

As a rule, Government should not subsidize anything. But when national security is threatened by imported oil dependency, development of other energy forms should be accelerated and the Government should play an important role to see that this is accomplished.

Lockheed Missiles and Space Company

No comment.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

The Government should subsidize some energy R&D. We have no problems with the Government funding nuclear energy development. Nuclear energy looks like it could have a very attractive payback and could solve the nation's energy problems. Concerning funding PV R&D, we think much of the funds expended on PV have been wasted. To this extent the budget cuts will not hurt if the right things are cut. However, funding for high efficiency and concentrator cells should be continued.

There should be zero subsidies for oil and gas, zero for synthetic fuels, and further R&D funding in coal.

Motorola, Inc.  
Semiconductor Group

No comment.

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Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

Emphatically yes. During the next decade and beyond, the three major problems facing the world will be energy, water, and food production. These problems will dominate man's thinking during the next decade--especially if we ignore them as problems right now.

SES, Inc.

No comment.

SILTEC, Inc.

Yes, the Government should continue or increase funding for technology development and applications as well as advanced research and development.

Spire Corporation

The Government should subsidize any form of energy development that will help the country reach energy independence.

Robert W. Willis, President  
Solenergy Corporation

The Government should subsidize energy R&D. We should have a balanced program of subsidizing nuclear energy as well as PV.

Dr. Milo Macha, President  
Sollos, Inc.

No comment.

Ronald S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

Since other forms of energy production are being subsidized, PV should also be subsidized.

Varian Associates, Inc.

Yes. The Government should fund R&D primarily, both to improve the technology and to develop lower costs in producing PV cells. The Government can better help in development of the technology rather than commercialization. Commercialization should be left to the private sector, but in R&D, the Government is in a much better position to fund and invest in competing technologies than are private companies. Private companies would tend to

select what appeared to be the best or the technology closest to being commercial and that may not ultimately turn out to be the best one. The government, on the other hand, can afford to fund and do research in competing technologies in hopes of developing the best one rather than the one that is closest to the market place at the present time.

Westinghouse Electric Corporation

No comment.

Other comments

--Yes, it should. Energy at the lowest possible cost is almost one of the inalienable rights of each individual, and the Government should assist this to come about. Beyond that, development of alternative energy forms is in the national interest to accomplish in the quickest possible time. Development of these alternative forms will undoubtly come about in due course through the normal market place, but whether or not the country as a whole can afford to wait for the due course of market development is rather questionable.

--Yes, both the oil and nuclear industries were heavily subsidized by the Government for many years. So heavily, that solar will never be able to make it on its own against these industries unless Government help is given in a proportionate amount or it is removed from the oil and nuclear industries. Even then, the size of the task of developing solar energy is so huge that additional Government funds may still be required. The Government should assist the more promising energy technologies equally, rather than prematurely selecting one over the other to fund before they are equally developed. One should also remember that U.S. oil dependency came about primarily because of the imbalance in Government assistance to the oil industry.

--The Government should be involved in early R&D efforts to help foster new ideas. Our firm has some good research ideas, but the time frame is too long to fund their development. Concerning PV, the Government should fund R&D to improve the fundamental understanding of the conversion efficiency of PV cells.

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22. Did your company plan its photovoltaic capital investment on the basis of the Federal Government's commitment to spend \$1.5 billion on photovoltaic development during the next 10 years? How will a Government withdrawal from this commitment affect your company?

Howard L. Morse  
Vice President and General Manager  
Alternate Energy Division  
Acurex Corporation

No, Acurex did not make its PV investment on the basis of the Government commitment to spend \$1.5 billion on PV development over the next 10 years. Acurex has a very modest PV capital investment and it was not made contingent upon the Government commitment. However, if the Government withdrawal stretches out the point in time when PV cells are reduced in cost, it will hurt our ability to sell solar systems and PV systems.

Anthony Adler

The question is not applicable.

AMETEK, Inc.

AMETEK did not pursue PV R&D efforts based on the Government's commitment. The Government is just too unpredictable for any company to have that kind of confidence in it.

ARCO Solar Industries

No, we have not based our plans on the Federal Government program.

Dr. Karl W. Böer

No comment.

Frederick Schmid, President  
Crystal Systems, Inc.

I entered the PV business because I saw that there was an immediate problem in silicon production. I needed Government funds to get started.

DSET Laboratories, Inc.

No, DSET did not plan its capital investment in solar testing because of the Government's \$1.5 billion commitment, but to the extent that the Government programs have accelerated the normal growth of the industry this has translated into increased demand

for our services and we have responded with the capital investment to provide these services. A Government withdrawal from the PV industry at this point would slow the growth of the industry and would jeopardize investments made in support of the PV industry.

Exxon Enterprises

We did not plan on building a photovoltaics business based on Government support. We entered the business in the mid-1970s based on the potential for PV to grow into a substantial, profitable business. The industry is not yet profitable and Government withdrawal of some of its support will not affect that.

Ford, Bacon & Davis Utah, Inc.

Yes, however, Ford, Bacon & Davis is not a manufacturer of PV cells, panels or arrays. We are a large engineering design and systems constructor that works in many fields. Designing and constructing PV systems is a relatively small percentage of our business. Of course, a commitment to spend \$1.5 billion on PV development would attract the attention of any organization with capabilities to assist in this area. We set out into foreign markets confident that U.S. developments would support our goal to be a high quality leader in the engineering and design of integrated and stand-alone PV systems.

R. Douglas Wright, President  
Free Energy Systems, Inc.

No, we did not plan one dime of our PV capital investment on the basis of the Government's commitment.

Dr. Peter E. Glaser

This question does not apply, as Arthur D. Little is a large international consulting company covering many fields. It has performed PV R&D on silicon ribbon growth. Its PV R&D work was not Government-funded.

John V. Goldsmith

(a) Yes, Solarex did consider in its plans such Federal actions as the public law called "The Photovoltaics Act of 1978."

(b) The withdrawal will not hurt Solarex significantly. However, we have to reconsider how to apply our own risk capital. The present administration does not appear to be interested in the photovoltaic industry, consideration of photovoltaics as an alternate energy source for our nation's needs, nor even value the photovoltaics industry's commercial significance to the United

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States. This lack of interest may prove to be a major benefit to the photovoltaic programs of other nations and their industries.

### Lockheed Missiles and Space Company

Lockheed's PV R&D work is fully Government funded. Lockheed will not continue the work if the Government stops funding it.

Wesley G. Mathei, Manager  
Solar Products Division  
Microwave Associates, Inc.

No, Microwave's PV involvement is not based upon a Government commitment. We are just exploring the field.

Motorola, Inc.  
Semiconductor Group

No, Motorola did not base its PV investment upon the Government's commitment to spend \$1.5 billion on PV. Motorola has been very willing to take advantage of the Government's market and technology acceleration, but has not allowed itself to become dependent upon it. The Government withdrawal may slow Motorola down a bit, but will not otherwise hurt it.

Robert W. McGinnis  
Vice President and General Manager  
Photowatt International, Inc.

I was a participant in forming the plan that was submitted to Congress that resulted in the passage of the legislation in 1978 that committed the Government to spend the \$1.5 billion over a 10-year period, but, even then, I did not believe that the Government could maintain consistency over that long a period of time, and thus have not relied upon that Government commitment as a basis of capital investment decisions.

SES, Inc.

SES did not plan past, present or future PV capital investment on the basis of the Federal Government's commitment.

SILTEC, Inc.

Yes. SILTEC had recently (before the announced budget reduction) been considering the feasibility of establishing a PV manufacturing facility and entering the PV market. The Government withdrawal from its commitment will not only prevent us from entering the PV cell market, but we have stopped all technology development effort due to the cutoff in Government contract funding.

We were negotiating with JPL for two contracts in the Technology Development and Applications program area, but because of the FY 1982 proposed budget cutbacks, these negotiations are on hold at JPL's initiative. If allowed to proceed, we believe that the Technology Readiness Demonstrations for both Advanced Continuous Liquid Feed Czochralski Crystal Growth and Low Kerf Simultaneous Multiple Ingot I.D. Slicing (Wafers) would require only 18 months to complete. Successful completion of these two projects would meet the goals of the Low Cost Solar Array Program and provide the technology to sharply reduce the cost of PV solar cells within the schedule as defined in the program goals.

Market research indicates that the PV industry could be very large, both worldwide and in the United States. It is a cause for great concern that if the U.S. Government stops funding Technology Development now, the market will be taken over by foreign countries and companies and the U.S. PV industry may not recover.

Spire Corporation

Our corporate strategy was based on heavy Government R&D expenditures. If the Government withdraws, we will have to do a complete reassessment because we are just moving into the commercialization phase of our PV effort. We are not sure of the total effect on the company of a Government withdrawal.

Robert W. Willis, President  
Solenergy Corporation

I would not be in the PV business if I had planned my company strategy based on the Federal Government's commitment.

Dr. Milo Macha, President  
Sollos, Inc.

No. Sollos was formed in 1975; the Government commitment was made in 1978. However, at the time that I organized Sollos, I did it because I had new ideas for producing PV cells that I did not think anyone else had, and I thought that perhaps I could obtain some Government support and funding for new ideas which could produce the long-awaited cost breakthrough.

Ronald. S. Scharlack, Manager  
Solar Systems  
Thermo Electron Corporation

This company entered the solar business on the basis of an AID project. I was not with the company then so I am not sure what the underlying rationale was for getting involved at that time. If the Government withdraws from this commitment, the company will discontinue PV development work.

Varian Associates, Inc.

Yes, Varian's PV R&D program is funded largely from Government funds at this point. We spent several million dollars of our own funds to get started, and have shared funds in several cases on Government contract funds received since then. A Government withdrawal will reduce or stop our work in PV. The company would not continue a large PV R&D program with its own funds because the payback period would be too long.

Westinghouse Electric Corporation

Westinghouse did not plan its PV capital investment on the basis of the Government commitment.

Other comments

--No, we do not think so. The company was into PV work well before the Government made its commitment in 1978. The company made its commitment on the basis that it thought that PV would be a growth industry. However, one of the reasons that it thought it would be a growth industry was because of the Government participation in developing the technology.

In February 1981, we purchased a small company which makes PV powered irrigation pump systems--complete systems including pumps (made in Germany), power conditioning equipment, and PV panels. We are now marketing these systems in LDCs. This production and marketing effort is not dependent on the DOE. However, it will continue to be dependent upon expenditures of development assistance funds by AID, the World Bank, and other assistance agencies, since the small, poor farmers in LDCs do not have the capital to buy these systems on their own, yet they are quite important for their economic development.

--No, our firm did not expect the Government spending to continue in the first place, so it did not base its investment decisions upon that point.

--No, the company did not base its PV investment on the Government's commitment to spend \$1.5 billion on the industry for a 10-year period.

EFFECT OF BUDGET PROPOSALS ON  
INTERNATIONAL SOLAR ENERGY AGREEMENTS

At the beginning of 1981, the United States may have had as many as 49 cooperative projects under international solar energy agreements in existence or under consideration (DOE officials were unable to provide the precise number). These ranged from extensive cooperation on solar research, development, and demonstration (RD&D) projects to merely a sharing of information. The largest of these agreements is with Saudi Arabia.

The originally proposed solar energy budget reductions included funding only for the U.S.-Saudi Arabia agreement. At the time of our review, SERI officials said that eliminating the other agreements could somewhat delay the U.S. domestic program, even though projects under these agreements have not been directly tied to domestic programs.

SAUDI ARABIA AGREEMENT

In October 1977, the Governments of the United States and Saudi Arabia formally signed an agreement creating a 5-year, \$100-million program for cooperation in the field of solar energy. The broadly stated goal of this program, known as SOLERAS, is to promote the development of solar energy technologies for the benefit of both countries and of the world. The first year of program activities was 1979. Projects conducted under the program include

- a photovoltaic power system for two Saudi villages;
- four solar-cooling engineering field tests near Phoenix, Arizona, and four solar-cooling laboratories at Saudi universities;
- water desalination projects in both Saudi Arabia and the United States;
- solar greenhouse projects for pilot plants in one country or the other (site had not been chosen); and
- several educational projects.

The SOLERAS program is managed by an Executive Board consisting of four representatives from each country. The SOLERAS Executive Board has designated SERI as the operating agent responsible for implementing program activities. The program is funded equally by each country, with Saudi Arabia matching U.S. appropriated funds for each project approved by the Executive Board. The total \$100 million funding is divided over the 5-year period as follows.

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<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>Total</u>
----- <u>(millions)</u> -----					
\$15	\$25	\$25	\$25	\$10	\$100

Current status

Through March 1981, the Executive Board has approved over \$45 million in SOLERAS expenditures. Current and planned funding for the program, which ends in December 1983, is shown below.

<u>Project</u>	<u>Approved funding through March 1981</u>	<u>Planned funding</u>	<u>Total</u>
----- <u>(000 omitted)</u> -----			
Photovoltaic village power system	\$28,663	\$ 899	\$ 29,562
Solar greenhouses	2,000	16,000	18,000
Active cooling engineering field test	3,970	295	4,265
Cooling laboratories	400	9,500	9,900
Desalination	4,000	20,000	24,000
Workshops/courses	497	1,050	1,547
Program administration	6,117	6,609	12,726
<b>Total</b>	<b>\$45,647</b>	<b>\$54,353</b>	<b>\$100,000</b>

The progress of each project as shown in progress reports is listed below.

1. Saudi photovoltaic village - System design and fabrication has been completed. Installation and construction will be complete in August 1981. Operation, evaluation, and training will then continue until the December 1983 project end date.
2. Solar greenhouses - Three companies have been selected to begin an analysis of a commercial-sized plant and preliminary design of a pilot plant to demonstrate the technical and economic feasibility of commercially viable solar controlled-environment agriculture facilities (greenhouses) in hot, arid zones. In January 1982, awards are to be made for detailed design, construction, operation, and evaluation of two pilot plants.
3. Active cooling engineering field test - Design, fabrication, and installation have been completed. Operation and evaluation will occur during summer cooling seasons of 1981 and 1982.

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4. Saudi university cooling laboratories - Detailed design and analysis of laboratories for conducting solar-cooling research at four Saudi universities was initiated in January 1981. The construction and operation phase of the project is expected to start in November 1981 after Executive Board approval of funding.
5. Solar energy water desalination - Five contracts were let for systems analysis of a commercial-size plant and preliminary design of a pilot plant. These will be complete by August 1981, at which time two contractors will be selected for detailed design, construction, operation, and evaluation of the pilot plants, one to be located in the United States and one in Saudi Arabia.
6. Workshops/courses - Joint workshops for solar cooling and solar water desalination have been held and additional workshops are planned. Two-week courses for U.S. and Saudi graduate students in solar technologies were held in 1979 and 1980 and additional courses are planned.

#### Benefits to U.S. domestic solar program

Although SERI officials could not directly relate goals of SOLERAS projects to those of the U.S. domestic program, they cited the following benefits of the projects to the U.S. solar program.

##### 1. Saudi photovoltaic village

This project provides field-testing of state-of-the-art concentrator photovoltaic systems complementing the respective domestic program. SERI officials told us that the major U.S. project contractor, as a result of its efforts on this project, has been able to realize a significant reduction in its production costs. (However, the contractor presently produces photovoltaic systems only for U.S. Government projects and not for the commercial market.)

##### 2. Solar greenhouses

This project also tests technology to produce industrial heat and electricity, which DOE considers promising in the near term. It uses combinations of solar technologies not funded by the domestic program.

3. Active cooling engineering field test and solar-cooling laboratories

Because of significant budget reductions in the domestic solar cooling program, these SOLERAS projects are considered important for fulfilling goals of the U.S. domestic program and for meeting congressional mandates for technology advancement.

4. Solar energy water desalination

Desalination is considered a promising candidate for economically viable solar industrial heat application. Because of previous lack of funding by DOE and the Department of the Interior, the SOLERAS project will provide field testing of technology that had previously been targeted for testing under the U.S. domestic program.

5. Workshops/courses

Workshops provide for an interchange of ideas and opportunities for modifications of domestic programs. Graduate research courses provide valuable contributions to state-of-the-art technology advances.

Effects of proposed budget adjustments

Although the new administration's proposed budget reductions did not reduce the SOLERAS program's total funding, it deferred some FY 1981 funding to later years, which may adversely affect some SOLERAS projects.

The United States and Saudi Arabia each deposit their share of the total year's funding for SOLERAS with the U.S. Treasury Department early in the calendar year. Then, based upon actions taken by the Executive Board, the appropriate funds are withdrawn for use on the various SOLERAS projects. The budget authority for calendar year 1982 has been set by the Executive Board at \$25 million, or \$12.5 million from each country. However, DOE has included in its fiscal year 1982 budget only \$4 million under the international solar program line item, all of which is for continuing the SOLERAS program. Program officials plan to make up the remaining \$8.5 million shortfall for 1982 with a \$4-million carryover from the fiscal year 1981 budget and an increase of \$4.5 million in the fiscal year 1983 budget. SERI officials believe that this funding arrangement may cause some important SOLERAS procurements to be delayed, including the desalination and solar greenhouse projects. A SERI official told us that, because of these procurement delays, all the evaluation and performance data may not be collected before the end of the SOLERAS program. He said at least \$11.5 million of the \$12.5 million would have to be available early in January 1982 in order to avoid procurement delays.

The most significant delay, SERI officials told us, would be with construction contracts for the two solar water-desalination pilot plants. Officials said that funding delays would probably cause the team of government and industry representatives to disband after the detailed design work, which is to be completed late this year. They said a slowdown of SOLERAS funding could reduce the program to only one plant - or even none. They believe that any disruption in the projects' progress would cause increases in funding due to rising engineering and hardware costs. They estimate that almost \$25 million will be needed to complete the final design and construction of the two desalination plants.

According to SERI officials, the solar greenhouse project would be affected to a lesser degree, since contracts for the detailed system design work will not be issued until December 1981 or January 1982. They estimate that about \$10 million to \$14 million will be needed to complete the detailed design, construction, and operational evaluation of the two proposed plants.

SOLERAS program officials at SERI told us that budget reductions or delays will not affect the Saudi photovoltaic village project or the active cooling engineering field tests, since these projects have been almost completely constructed and operational results are expected from them this year.

Although SOLERAS officials we contacted generally declined to comment on the potential effects on foreign relations of funding reductions or delays, one official said the Saudis would be very upset if the desalination project is delayed or reduced in scope. Another SERI official expressed the Saudi concerns as a fear that the United States would renege on the SOLERAS agreement or unnecessarily force a delay in project funding, thereby adversely affecting technical progress made on the projects.

#### OTHER INTERNATIONAL SOLAR AGREEMENTS

Other international solar energy agreements managed by SERI have been or are expected to be curtailed or revised as a result of expected budget reductions.

Until June 30, 1981, SERI managed DOE cooperative solar energy agreements with Italy, Mexico, and Israel in addition to the SOLERAS program, and was conducting a feasibility study with Brazil to examine potential areas of cooperation. As of that date, DOE transferred responsibility for management of international agreements to DOE headquarters.

#### Italian agreement

On October 17, 1979, the United States and Italian Governments signed a Memorandum of Understanding on energy cooperation

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which included seven solar energy projects estimated to cost \$4.5 million. These projects cover solar thermal and photovoltaic conversion, the passive use of solar energy for buildings, and solar energy information exchanges. The Italians have stressed the importance of these cooperative projects in their negotiations with their U.S. counterparts.

SERI has begun procurement actions for the two largest Italian projects totaling over \$3.2 million. One of these projects involves the design, construction, and performance evaluation of two advanced solar energy conversion systems (thermal and photovoltaic) at the same location with the same electrical load demand. The other is a small photovoltaic system to be used for limited applications in a rural residential area. SERI has held bidders' conferences with prospective contractors and has issued requests for proposals.

Although the Italian Government stressed the importance of these cooperative projects and the procurement process has been started, DOE presently does not plan to fund these two projects under the agreements because of anticipated budget cuts.

#### Mexican agreement

In February 1979, the Presidents of the United States and Mexico signed a Memorandum of Understanding on Science and Technology Cooperation, preparing the way for a series of cooperative projects in energy technologies. A subsequent meeting of representatives of both countries selected seven areas of joint work that would be mutually beneficial. As a result of budget reductions, DOE has proposed to the Mexican Government a revision to this agreement to include only four major projects lasting 7 to 32 months. They are:

<u>Project</u>	<u>U.S. funding</u>	<u>Description</u>
Passive cooling	\$250,000	Design and construction of a passive solar experimental facility for solar experiments
Solar refrigeration	\$ 40,000	Development of a design matrix for solar-powered refrigeration devices to be used as a tool by engineers and architects
Photovoltaic technology	\$ 70,000	Training of two scientists from Mexico in amorphous silicon photovoltaics and subsequent development of a photovoltaic laboratory in Mexico
Solar collector test facility	\$ 40,000	Development of a detailed plan for a solar collector test facility

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The United States has presented this revision as a proposal to the Mexican Government and has asked for Mexico's approval of the projects and an indication of the amount of funding which Mexico would be prepared to invest in the projects. As of September 2, 1981, the Mexican agency responsible for the first three projects (the Consejo Nacional de Ciencia y Tecnologia) had agreed to them in principal. Details still remain to be resolved. The agency responsible for the fourth project (Direccion General de Aprovechamiento de Aguas Salinas y Energia Solar) had not yet replied.

#### Israel agreement

Based upon discussions held with Israeli officials in September 1979, a blanket agreement between the United States and Israel was drawn up for cooperative research projects. Although negotiations on the blanket agreements were not successful, three individual project agreements were signed in August 1980. One of these projects was later dropped because of planned budget reductions and because it duplicated other ongoing U.S. domestic research and did not meet the U.S. needs for petroleum replacements. The remaining two projects are as follows.

<u>Project</u>	<u>Funding</u>	<u>Description</u>
Passive climate control tests	\$450,000 (U.S.) \$150,000 (Israel)	Measurement, evaluation, and comparison of the performance of various passive climate control techniques
Luminescent planar solar collectors	\$660,000 (U.S.) \$210,000 (Israel)	Research and development of novel photovoltaic devices

SERI and DOE officials have discussed with Israeli officials the potential for additional cooperation in aquatic biomass R&D, although no formal joint government projects are now planned. A SERI official told us that previous efforts to initiate projects on solar ponds, a technology in which Israel has specialized, have not been successful, primarily because the United States has not yet completed a domestic program plan for solar pond development and the Israelis are concerned about the possible divulgence of proprietary information.

#### Future cooperative efforts

SERI officials have begun discussions with Brazilian officials on cooperative efforts in the biomass area. Discussions are centering on liquid fuel production (ethanol and methanol) and gaseous fuel production (methane). SERI officials believe the potential benefits from cooperation in the development of these areas to each country are significant. One official cited Brazil's extensive practical experience in the development and commercial production of bioconversion

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technologies as benefiting the U.S. bioconversion effort. Conversely, the advanced state of the U.S. technology would be of significant benefit to Brazil. Although DOE has no funds committed for cooperative efforts with Brazil, SERI is proceeding with a feasibility analysis of potential areas in which U.S. and Brazilian industries can cooperate.

#### EFFECTS OF CHANGES IN AGREEMENTS

Most SERI officials we contacted believe that projects under these agreements are for the most part politically motivated and stated that the projects are not directly tied to the domestic program and not all of them benefit the U.S. domestic program from a technical standpoint. SERI officials believe that international projects should directly support the domestic program.

Although SERI officials could not indicate specific effects on the domestic solar effort, they generally believed that reduced funding for international solar agreements would delay somewhat the progress of the domestic programs. One official felt that the use of international cooperative agreements could be very beneficial in a time of domestic budget restraint since the United States could obtain significant benefits for a 50 percent investment in an agreement directly tied to a domestic solar program.

## APPENDIX IV

### SOLAR ENERGY IN FRANCE

Within the Government of France, the Commissariat a L'Energie Solaire, known as "COMES", has full authority for the National Solar Energy Program. Established in 1978, COMES defines solar policy and controls the solar budget for all government agencies. The current solar program emphasizes the diversification of energy sources in order to reduce France's dependence on imported oil. Specific objectives included in the program call for alternative energy sources to meet 10 percent of French energy needs by 1990. This accounts for 73-88 million barrels <sup>1/</sup> of oil equivalent (MBOE), to be produced from non-petroleum energy sources as follows.

Biomass	55.0 - 66.0 MBOE
Direct solar energy	9.5 - 11.0 MBOE
Geothermal	5.9 - 7.3 MBOE
Small hydro plants	2.9 - 3.7 MBOE
Wind	Less than 3.7 MBOE
 Total savings	 73.3 - 88.0 MBOE

A COMES official stated that COMES intends to meet this goal by concentrating on two areas: biomass and direct solar heating (primarily passive systems). Currently, there are no major domestic solar electric (photovoltaics) programs except for some communication research. Photovoltaic research for domestic use is not emphasized, because France has devoted much time, money, and research to nuclear energy. During 1980-90, the use of new energy sources is expected to increase from 1.5 to only 5 percent, whereas nuclear energy will increase from 7 to 30 percent. Gas and coal will remain stable at 30 percent of consumption, while hydropower use will decrease from 8.5 to 5 percent. Total dependence on petroleum is expected to drop from 53 percent in 1980 to 30 percent in 1990.

### SOLAR ENERGY BUDGET

Government support of research for alternative energy sources continues to increase. Although not justified on economic reasons, alternative energy sources are pursued because of the role they can play in diminishing costs of imported oil and increasing energy independence. In addition, solar energy technology offers export possibilities, especially to developing countries.

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<sup>1/</sup>Converted from tons to barrels at 7.33 barrels per ton, an approximate average of petroleum specific gravity ranges. It equates to API 33 at 15.6°C.

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During its 3 years of existence, COMES staff has grown from 3 to about 65 people. Its budget increased from \$17.8 million <sup>1/</sup> in 1978 to \$39.6 million in 1981. In 1981 alone, COMES gained 20 additional positions and a 42 percent increase (\$11.8 million) in its operating budget. COMES expects this budget to continue to grow over the next several years.

The three main priorities for COMES in 1981 as indicated by budget allotments are (1) biomass - \$10.4 million (26 percent), (2) solar heating and cooling of buildings - \$9.5 million (24 percent), and (3) photovoltaics - \$7.1 million (18 percent). The remaining 1981 budget is allocated to (1) thermodynamics - \$4.2 million (11 percent), (2) wind - \$800,000 (2 percent), and (3) operating expenses (publicity, training, etc.) - \$7.5 million (19 percent). As previously mentioned, the solar energy budget emphasizes biomass to reduce domestic dependence on imported oil supplies. However, photovoltaics is justified on the basis of its export potential, rather than domestic use.

Of the \$39.6 million available in the COMES 1981 budget, the following fields of activity are expected to be pursued.

	<u>(millions)</u>
Research	\$10.7
Industrial policy	8.7
Market development	6.2
Demonstration projects	4.8
International program	2.2
Information and promotion	1.5
Capital investments	0.9
Operating costs	<u>4.6</u>
 Total	 <u>\$39.6</u>

In 1980, the Government of France appropriated, in addition to the funds allocated to COMES, approximately \$176.3 million for the following organizations to develop renewable energy.

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<sup>1/</sup>1978 and 1980 dollar figures herein were converted from French francs (FF) at the annual average exchange rates of \$1.00=4.5128 FF and 4.2260 FF respectively. The 1981 figures were converted at the January-May 1981 average rate of \$1.00=5.0347 FF.

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(millions)

Ministry of Industry	\$ 12.3
Other Ministries (such as Environment, Universities, and Equipment)	34.1
Public organizations	32.2
Local governments	11.8
European community	4.3
Industry R&D	10.6
Investments in energy pro- duction (solar water heaters, wood heat)	<u>71.0</u>
Total	<u>\$176.3</u>

Government spending on "new energies" as a whole, is expected to surpass 1 billion FF in 1981 (\$198.6 million). The French Government expects such emphasis to lead to 40,000 to 50,000 new jobs by 1985.

An analysis of the total solar energy budget was not available for 1980-81. However, in 1979, the French Government allocated 60 percent of its solar budget for research and development, 29 percent for demonstrations, and 11 percent for investments.

#### GOVERNMENT SUPPORT OF THE SOLAR INDUSTRY

##### Research and development

The French Government has financial or direct staff participation in practically all of the university and public sector research and development and also plays an important role in private endeavors. Of the total solar budget in 1979, 61 percent was used directly by the private sector and 39 percent for public research and housing investments. Financial assistance to the public sector comes through the Centre National de la Recherche Scientifique (CNRS), the principle French agency responsible for solar energy research and development. Within CNRS, the Interdisciplinary Research Program on Solar Energy Development (PIRDES) is specifically responsible for facilitating public and private solar energy research. The CNRS provides scientists and engineers to join research groups at universities. In addition, PIRDES has been involved in its own projects, such as the study and development of two types of concentrating collectors--the Thermodynamic Energy Kilowatt (THEK) and the Production of Energy in an Isolated Region by the Limited Concentration of Solar Energy (PERICLES).

A March 18, 1980, report by the U.S. Consulate General in Marseille on solar energy developments in the Marseille area stated that:

"In the private sector, the CNRS provides financial support to selected projects, usually limited to those proposed by major French companies. In earlier years such help was limited to one-fourth of costs. In 1979, the Government upped its support to one half of expenses in an effort to encourage more private sector activity. Thus far industry has remained luke-warm about the government's offer because government's policy and practices remain uncertain with respect to ownership of the know-how and patents developed in private industry research projects receiving government assistance."

Although the 50 percent subsidy may sound large, an Embassy official felt that the coal, gas, and especially the nuclear industry may receive as much, if not more, government assistance. It is very difficult to separate government and private funds because they work so closely together. For example, ELF Aquitaine, a 70-percent government-owned French national oil company, is involved in many energy research projects with private firms.

#### Commercialization

The French Government provides incentive grants and loans to public and private institutions, industries, and even individuals to perform solar research or to buy solar-equipped homes. Some of these funds are distributed through local community organizations. Major domestic commercial programs include providing low-interest-rate loans to make solar housing improvements and providing financial assistance to businesses making major improvements to conserve energy or use new energy sources. The commercialization effort includes demonstration projects to show that solar homes are economic in energy use and inexpensive to set up. Published sales figures are not yet available.

In the world market, the French photovoltaic industry already has a significant role, and, through government support, plans to maintain, if not increase its role. Presently, the French are right behind the United States in photovoltaic equipment sales, particularly in exports to developing countries. To cope with the steadily rising competition, one of COMES's functions is to discover and open up future markets to assure the French industry of rapid and well-balanced development. In March 1980, a 6-year plan for photovoltaic industrial growth was adopted with the goal of commanding a major share of the world market in the years ahead. The plan will achieve this by providing government support at every level--research, development, mass production, and marketing. Government aid to the industry will include grants from COMES.

In a move to strengthen the French ability to compete in the world photovoltaic market, COMES has encouraged consolidation of the French PV industry. Under its urging, two giant

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companies--Compagnie Generale d'Electricite (CGE) and ELF Aquitaine--merged their photovoltaic activities in 1980 into a single new company, Societe Francaise des Photopiles, financed by ELF Aquitaine and COMES. Shortly after that, La Radiotechnique-Compelec (RTC), a 94 percent-owned subsidiary of the Dutch electronics group, Philips, also joined Societe Francaise des Photopiles. Under the agreement, RTC, which had produced photovoltaic cells in France since 1961, turned over all of its photovoltaic operations and facilities to Photowatt International, S.A., a wholly-owned subsidiary of CGE. Under this arrangement, Photowatt is to produce PV cells and arrays for CGE, ELF Aquitaine and Philips market outlets. At present, the Societe Francaise des Photopiles is owned 14 percent by RTC, 35 percent by ELF Aquitaine through its wholly-owned subsidiary, ELF Energies, and 51 percent by CGE through two wholly-owned subsidiaries, Compagnie Industrielle des Piles Electrique (CIPEL) and Societe des Accumulateurs Fixes et de Traction (SAFT)--both of which are major worldwide battery manufacturers.

Photowatt International, S.A., in France, and its sister company, Photowatt International, Inc., in Phoenix, Arizona, were formed in 1979 through a joint venture between CGE (via its two subsidiaries, CIPEL and SAFT) and the Dyneer Corporation of the United States. Under the agreement, the photovoltaics operation of Sensor Technology, Inc., which had recently been purchased by Dyneer, was transferred to Photowatt International, Inc. Since then, SAFT has acquired the CIPEL and Dyneer holdings and owns Photowatt International, Inc., outright. The U.S. company, Photowatt International, Inc., is owned by SAFT Corporation of America, an affiliate of SAFT of France. Photowatt International, S.A., and Photowatt International, Inc., have a cross licensing agreement through which the French company concentrates its R&D on systems and silicon and the American firm works on manufacturing techniques. Both produce PV cells and modules.

The merger of RTC into the Societe Francaise des Photopiles coupled with a decision by Thomson-CSF earlier this year to terminate its PV joint venture with Exxon's Solar Power Corporation, leaves only two major producers of photovoltaic cells in France--Photowatt International, S.A. and a smaller company, France-Photon. France-Photon was formed in 1978 by a joint venture between Moteur Leroy-Somer (50 percent) of France and the Solarex Corporation (50 percent) of the United States. Originally, France-Photon assembled PV modules using PV cells produced in the United States by Solarex, but it now produces cells itself under a Solarex license.

#### International cooperation

COMES is responsible for international cooperation either as a representative of the French Government in the case of formal international agreements or through direct relationships

with foreign organizations. COMES also has responsibility for promoting solar energy applications in French overseas territories and in developing countries. In carrying out these responsibilities, COMES can provide a variety of services, including (1) R&D design studies, (2) technical expertise, (3) project management, (4) financial studies/assistance, (5) promotion services, and (6) government program management for all energy related matters.

COMES officials stated that besides France, only the United States, Germany and possibly Japan have formal solar energy programs. Each of these countries has something to offer in the way of technology or market development capabilities. It is a function of COMES to foster the acquisition of foreign solar interests such as purchasing or entering into joint ventures with U.S. companies. It is a policy of France not to import foreign manufactured products if domestic capability exists because of the negative effect on the country's balance of payments, jobs, and other economic factors. COMES officials stated that if France lacks domestic capability, its objective is to acquire such capability. However, France is open to joint ventures or licensing agreements when the mutual interests of both parties can be satisfied. U.S. Embassy officials have noted a trend in U.S./French firms joining efforts for solar energy equipment production. An Embassy report states that such associations benefit both French and American firms because:

- French firms will benefit from American financial support and U.S. photovoltaic technology developed during the 1960s with the space program.
- American firms expect to reach African markets, which offer tremendous opportunities.

COMES officials stated that France offers no specific assistance for exports but, since solar is popular now, more funds may be going to that industry to support commercialization and research projects. France exports very little solar equipment except solar cells (over 90 percent of its production) to developing countries. No statistics were available, but a U.S. Embassy official said he believes that many French solar exports have resulted from French Government demonstration projects, grants, or long-term loans. Many developing countries lack the financial capability to buy such technology without assistance. COMES officials believe the eventual market will be in developed countries because of the capital requirements.

SOLAR ENERGY IN THE FEDERAL  
REPUBLIC OF GERMANY (FRG)

GERMAN SOLAR ENERGY PROGRAM

The main objective of current government-supported energy research and development efforts is to guarantee the continuation of the FRG's energy supplies at economically favorable costs. Current energy R&D is coordinated under a multiyear "Energy Research and Energy Technologies Program 1977-1980," which recognizes that the sources of energy normally available, such as oil, natural gas, and coal, will not meet further worldwide energy requirements. Therefore, the "Solar Energy Technologies Program 1977-1980" was established to develop new sources of energy to reduce German dependence on imported fossil fuels. Development under this program, however, is not solely restricted to those technologies that will meet only domestic need. Attention has been devoted to the development of technologies, especially photovoltaics, for use in developing countries. Multilateral and bilateral cooperative efforts are key activities aiding the solar program, both as a means of providing leverage to limited national funds and of exhibiting German technology and know-how throughout the world. The importance of the latter is that the international export market may prove to be the prime outlet for German solar products.

Recognizing the importance of alternative energy development, the FRG has substantially increased its funding for non-nuclear energy research, and, as the following table shows, funds available for solar-related R&D have been increasing since 1973.

	1981								
	1973	1974	1975	1976	1977	1978	1979	1980	(note b)
--- (millions of dollars) (note a) ---									
Solar, wind, biomass, geothermal	0.4	8.5	7.6	13.8	26.4	46.4	56.7	(note c)	
Total non- nuclear (includes above)	6.7	42.5	90.2	92.5	117.1	219.6	314.8	321.8	278.9

a/Converted from Deutsch marks (DM) to dollars at each year's average rate.

b/Approximate non-nuclear energy R&D funding in 1981 according to the U.S. Department of Energy scientific representative, Bonn, Germany.

c/Program details not available for 1981.

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### Solar thermal use

In the past, the FRG solar R&D program has emphasized solar thermal energy, primarily space and hot water heating. Early funding was aimed at enabling the industry to reach the international state of the art in converting solar energy into low temperature heat. Development of simple flat plate collectors and systems for the production of hot water has been successful. Current projects in solar thermal energy are aimed at optimizing system efficiency, lowering production costs, and accelerating market introduction. The production of solar thermal equipment is expected to result in both domestic and export sales.

### Electric use

The main objective in photovoltaic research is to achieve major advancements in solar cell fabrication techniques to lower the cost of production and raise the level of cell efficiency. AEG Telefunken is the principal contractor working on the photovoltaic program, with emphasis focused on developing an improved polycrystalline silicon cell. However, alternative solar cell materials (amorphous silicon, cadmium sulfide, and others) are also under investigation. The use of photovoltaic systems is not likely to achieve the significance of solar thermal because of Germany's climate, but R&D work on the electric uses of solar energy continues, based upon the export potential. In addition, the FRG is studying the technical and economic feasibility of obtaining electricity from Mediterranean countries.

### Wind energy

The FRG Government is also aggressively pursuing a wind energy program, whose objective is to optimize the most promising technical concepts with respect to economy, reliability, and control and to study the problems of integrating wind power systems into existing and future electrical grids. More than 40 projects are supported by this program, with emphasis placed on the large scale program Grosse Windenergie Anlage (GROWIAN).

### GOVERNMENT SUPPORT OF THE SOLAR INDUSTRY

The interest in solar energy has grown in the past 8 years or since the oil embargo. An Embassy official stated that the FRG solar industry has increased its technical capability to be very competitive in the world market. The rapid advancement of solar technology in the FRG can be directly attributed to the financial assistance provided to industry by the federal government for various R&D projects. The 1979 Annual Report for the Program on Energy Research and Technologies identified over 1,000 approved R&D projects (for coal, wind, solar, and other energy areas) amounting to approximately \$2.43 billion (con-

verted at the rate of 1.8329 DM to \$1.00). Of this amount, the government contributed \$1.43 billion, or 59 percent of funds required for all energy projects. Of the total government contributions, approximately 91 percent went to private industry and 9 percent went to public institutions.

The government believes that the importance of energy research and the development of new energy technologies for the national economy requires its active participation, because, as stated in the 1977-80 Energy Research and Energy Technologies Program:

"--Research, development and commercialization of new energy technologies today require time in the order of decades. This is particularly true of new high risk developments beyond periods of time which can be assessed in terms of industrial operation. This risk, and the exceptionally large investments required, often exceed the capabilities even of large industrial companies.

"--The optimization of technologies in the light of industrial operation does not automatically satisfy goals of a higher order. This is true in particular of aspects of environmental protection, protection of the public, workers' protection and the reduction of the dependence on imports."

As of matter of policy, the government strives not to fully fund R&D projects. Industry usually must contribute money to acquire government R&D funds. For its support, the government receives an irrevocable, free of charge and nonexclusive right to use R&D results. In special cases, full repayment is agreed to, subject to commercial success.

In 1979, the category of "new sources of energy" accounted for only 13 percent of the total cost of all approved projects. Research for "coal and other fossil sources of energy" accounted for 69 percent of the funds available, while "efficient use of energy" measures accounted for the remaining 18 percent. However, "new sources of energy," which includes solar, is one of the few areas for which high government support is considered necessary. The government contributed 72 percent of the funds required for all projects in this category, with several wind, thermal, and photovoltaic projects being funded at 100 percent. The 1979 budget and government assistance data for "new sources of energy" and

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some of the major projects included in the 1979 Annual Report are shown below.

<u>Program</u>	<u>Total cost of projects</u>	<u>Government contribution</u>	<u>Average support rate (percent)</u>
-----(000 omitted) (note a)-----			
New sources of energy			
Solar energy:			
Thermal use	\$ 49,727	\$ 43,244	87
Electric use	71,206	61,332	86
Biological and chemical	544	479	88
Combined systems	13,328	13,328	100
Supplementary measures	5,620	5,421	96
Total solar energy	<u>140,425</u>	<u>123,804</u>	88
Other non-fossil, non-nuclear sources of energy:			
Wind energy	71,217	66,527	93
Geothermal energy	96,592	34,951	36
Other sources	18,143	9,229	51
Total other	<u>185,952</u>	<u>110,707</u>	60
Total new energy sources	<u>\$326,377</u>	<u>\$234,511</u>	72

a/Converted from DM at 1979 average annual rate of 1.8329 DM to \$1.00.

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MAJOR PROJECTS

<u>Project title</u>	<u>Total cost</u> (millions) <u>(note a)</u>	<u>Government</u> <u>share</u> <u>(percent)</u>
<u>Thermal use</u>		
--Program for Future Investment: Installation of Solar Equipment in Federal Buildings	\$20.6	100
--Demonstration Project Landstuhl: Energy Saving and Solar Applications in Private Homes (Parts I and II)	3.5	100
<u>Electric use</u>		
--IEA: Small Solar Power Systems Project, Stage II	17.4	100
--Development and Production of Prototypes of Photovoltaic Power Stations	16.6	80
--Amorphous Silicon Solar Cells	1.7	80
<u>Wind energy</u>		
--Wind Energy Converter GROWIAN II	15.4	100
--Production, Development, Manu- facture and Test of the GROWIAN Rotor Blade	4.9	100
--Construction and Operation of the Large Wind Energy Converter GROWIAN	24.0	95.3
<u>Combined systems</u>		
--SONNTLAN Phase II	11.9	100

a/Converted from DM at 1979 average annual rate of 1.8329  
DM to \$1.00.

Embassy officials cautioned us that the close relationship of FRG Government officials to industry cannot be overstated. An industry official added that no German company would enter a new field simply because it sees an opportunity. The government's position toward a company in a specific industry must be considered. German officials believe it is necessary, considering the limited funds available, to direct solar R&D efforts by actually identifying which companies will work in a specific

area. Besides keeping specialists employed and expensive equipment in operation, this method of operation spreads the workload and keeps people employed. The government does not invest in large laboratories or buy expensive equipment; it uses an existing company's assets and R&D expertise. FRG officials believe the economic return is at least equal to the government's contribution to any company by simply creating jobs.

#### Commercialization

Many foreign governments such as the FRG and France try to eliminate internal competition, which they consider wasteful, by directing industry R&D and construction as well as commercialization efforts through the use of subsidies. However, within the FRG, much of the R&D funds made available to private industry are made available to advance market introduction domestically or in developing countries.

In addition to providing funds for the direct support of solar energy research, the FRG Government has actively supported domestic solar commercialization in the following ways.

- Provided investment allowances for the installation of solar systems for commercial purposes.
- Allowed tax reductions for installing new solar-assisted heating systems.
- Provided grants and tax benefits for the installation of energy savings equipment, to include solar systems.
- Installed solar hot water equipment in public buildings to demonstrate solar technology.

Government assisted demonstration projects are often used to exhibit German solar technology to the general public. In addition, demonstration projects foster the solar commercialization efforts of the government by

- providing the solar industry with the opportunity to test new solar components and facilities;
- diminishing the financial risk for producers of solar equipment by supporting the new market of solar techniques;
- providing the licensing authorities with the opportunity to obtain experience in administrative procedures; and
- contributing to a decrease of operational costs of public buildings.

## APPENDIX V

### International cooperation

The FRG participates worldwide on a bilateral or multilateral basis in numerous solar energy demonstration projects. The main multilateral efforts have been through international organizations, including the Committee on the Challenges of Modern Society (CCMS) of the North Atlantic Treaty Organization, the International Energy Agency (IEA) of the Organization for Economic Cooperation and Development, the Commission of the European Communities, and the United Nations. The IEA Small Solar Power System Project, in which two solar thermal concepts will be compared, is a good example of multilateral involvement. The FRG Government is providing 100 percent of the \$17.4 million necessary to fund stage II of the project.

Although no current list of the FRG's solar agreements was readily available, numerous bilateral cooperative agreements do exist with countries worldwide. Embassy officials stated that the German/Mexican "SONNTLAN" project is an excellent example of total involvement by the FRG Government and industry in promoting R&D construction as well as solar equipment commercialization. The prime contractor, Dornier, in coordination with various FRG contractors, is responsible for developing and installing a combined system to convert solar energy into recoverable heat and electricity as well as use of wind energy and waste heat in various Mexican locations. The FRG Government is providing 100 percent of the \$11.7 million necessary for phase II of the project.

## APPENDIX VI

### SOLAR ENERGY IN ITALY

Italy has only limited amounts of indigenous conventional energy resources; therefore it must depend on imports for more than 80 percent of its total energy requirements. Although it has the largest refining capacity in Europe, Italy imports 99 percent of its petroleum and about 50 percent of its natural gas. Its coal deposits are meager and of low quality. Both nuclear and geothermal energy presently play a minor role.

This dramatic energy supply situation has prompted Italy to emphasize energy conservation and new technologies. Italy's National Energy Plan, revised in 1978, outlines the government's energy strategies, and emphasizes the promotion of energy conservation, fuel substitution through the rational use of alternative sources of energy, and accelerated realization of a nuclear program. However, further legislation and administrative action are needed before the Plan can be fully implemented. A new National Energy Plan is being drafted which emphasizes, among other areas, accelerated development of solar energy applications.

### GOVERNMENT SUPPORT FOR SOLAR ENERGY

The Ministry of Industry and Commerce determines energy policy. In a recent speech, the Minister said that solar energy is one of the most important of the "new" energy sources. Italy's efforts to develop solar energy will include: (1) stimulating supply and (2) supporting demand. Supply stimulation will be through research, funding, industrial development, and, in some cases, support of industry reorganization to achieve an adequate level of technology and production. The Minister said that this may be necessary in the case of photovoltaics, for example.

Demand will be supported by various types of economic incentives and by demonstration projects for the more innovative technologies. Both of these actions, however will require legislation.

The National Committee for Nuclear Energy (CNEN), is the government energy agency and is responsible for research, development, and demonstration of nuclear power as well as for renewable energy technology and energy conservation. In 1980, CNEN's budget for solar energy and energy conservation projects was the equivalent of \$23 million. CNEN has also developed a 5-year plan which provides for an additional expenditure of \$341.6 million <sup>1/</sup> for research, development, and demonstration of renewable energy and energy conservation. The Parliament has yet to approve this plan.

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<sup>1/</sup>Converted from lire to U.S. dollars at May 1981 rate of 1,141.43 lire to \$1.00 as cited in the July 1981 issue of International Financial Statistics published by the International Monetary Fund.

Other important solar energy R&D is being carried out by government-owned holding companies. The three major companies are the National Electric Company (ENEL), which is the major electricity producer, the National Hydrocarbon Corporation (ENI) which controls the petroleum and natural gas companies, and the National Institute for Industrial Reconstruction which controls most of the transportation and communication systems. Each one of these holding companies has one or more subsidiaries working on solar energy R&D. Additionally CNEN, ENI, and ENEL are all responsible for commercializing solar energy.

To coordinate the entire energy sector, Italy has established a Permanent Energy Commission, whose members include the presidents of CNEN, ENEL, and ENI. This commission reports directly to the Minister of Industry.

The Italian Government is also encouraging the development of photovoltaic production capability by building the world's largest single photovoltaic installation to date. This project, referred to as the Delphos project, is a 1.15 megawatt (MW) flat plate photovoltaic array which can either stand alone or be connected to an electrical grid. Besides promoting the Italian industry, the project will give the Italians experience in design, construction, and operation of a large photovoltaic system which may be attractive for future export to developing nations or to remote communities. Several sources reported that the Italian Government is funding the project at about \$23 million.

#### INTERNATIONAL COOPERATION

The Italian Government also conducts solar programs in cooperation with the European Economic Community (EEC), the International Energy Agency (IEA), and with the United States through a bilateral agreement. The EEC is providing 50 percent of the funds for an Italian central receiver solar thermal power system, a so-called power tower, which will produce one MW of electrical energy for grid distribution. Italy is participating in three IEA agreements on various solar applications, including small solar power systems, solar heating and cooling systems, and hydrogen production. Under a Memorandum of Understanding with the United States signed on October 17, 1979, seven solar energy projects have been discussed. However, due to DOE budget cuts, certain projects are not presently planned for funding. (See Appendix III.)

We have identified two Italian manufacturers of photovoltaic equipment, Solaris and Ansaldo. Solaris is a joint venture of ENI and Solarex, S.A., which is partially owned by Solarex Corporation, a U.S. company. Solaris has a production capacity of 300 MW/year. Ansaldo is a member company of the National Institute for Industrial Reconstruction and has a current production capacity of 200 MW/year. The company's interest in solar energy is diversified and includes the production of photovoltaic cells and systems, wind driven generators, solar thermal technology and biogas

## APPENDIX VI

conversion. Ansaldo has production licenses with U.S. companies, Acurex Solar Corporation for parabolic trough collectors and Grumman Energy Systems for wind driven generators. Another U.S. company, Solec International, has recently announced a licensing agreement with Elios Technology of Italy. Solec, which recently sold a controlling interest to Pilkington Brothers, Ltd., of England, will work with Elios in establishing a one MW facility in about 8 months to 1 year.

Even though Italy has a subsidized, extensive, and relatively convenient electrical power grid, opportunities do exist in its domestic market for sales of photovoltaic systems. The grid system supplies more than 90 percent of Italy's residences with electric power. Solar energy has significant potential in the southern regions of Italy and in the islands of Sardinia and Sicily which are not as well served by the electrical grid. Furthermore, the climate in southern Italy is well suited for solar energy, and these regions are expected to receive continued emphasis for economic and industrial development.

The Italian Government is also interested in marketing solar products internationally. The Minister of Industry and Commerce sees a growing commercial potential in the developing countries, particularly in the Mediterranean area, where Italy has strong commercial ties. Interest has also been expressed in developing small scale photovoltaic systems for irrigation purposes in developing countries.

SOLAR ENERGY IN JAPAN

In 1974, Japan began a national technological development program called "Project Sunshine," that was organized by the Agency of Industrial Science and Technology in the Ministry of International Trade and Industry (MITI) to develop new sources of clean energy. Project Sunshine is a long-term, large-scale national project scheduled to run from 1974 to 2000, but with the short range goal of developing sufficient alternative energy sources to supply about 5 percent of Japan's total energy supply by 1990. It includes solar energy, geo-thermal energy, synthetic natural gas, coal and hydrogen fuels. In the broad solar energy area, the program includes R&D work on photovoltaics with emphasis currently on cell fabrication techniques--especially those related to mass production, low-cost silicon feedstock material, and R&D on amorphous silicon cells. All major PV cell technologies are covered. Table 1 shows the Project Sunshine annual budget from inception through 1980.

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During the first 5 years, the program focused on low-cost solar cell material research and thin-film technologies. In 1979, however, the strategy was shifted to accelerate the promotion of alternative energy sources and to smooth the commercialization of R&D results. At this time, the Japanese apparently decided to emphasize amorphous silicon technology. When Project Sunshine was organized in 1974, the photovoltaic division's steering group was divided into three major workshop committees. The first dealt with cost studies of various solar cell materials, manufacturing approaches, and array development; the second was concerned with the required power conditioning systems (batteries, current inverters, etc.) for various types of photovoltaic systems; and the third committee developed standards for cell performance measurement. In 1979, two more workshop committees were added to the steering group--one dealing with silicon raw material, and one dealing with amorphous silicon cell R&D.

Our information on the details of the Project Sunshine budget is incomplete, but various sources indicate that the photovoltaics budget for 1980 was 30 percent of the 1980 solar energy budget of \$42.1 million, or about \$12.6 million. One source stated that \$2 million went to amorphous silicon work and that figure would be doubled for 1981. By comparison, the United States' 1980 solar energy budget was \$579 million, of which \$150 million was for photovoltaics R&D, and \$4.5 million was for amorphous silicon R&D. U.S. amorphous silicon R&D was increased to \$5.3 million in the FY 1981 appropriation, was unchanged in the rescission request, and was projected at \$5.0 million in the FY 1982 revised request.

Japan's amorphous silicon R&D funds for 1981 were to be divided among the following recipients according to a ratio of 50 percent to industry, 30 percent to government laboratories and 20 percent to universities.

TABLE 1. PROJECT SUNSHINE ANNUAL BUDGET, 1974 THROUGH 1980  
(in millions of dollars and percent of total)  
(note a)

	1974	1975	1976	1977	1978	1979	1980
Solar energy	\$ 2.9	\$ 35.4	\$ 3.7	\$ 27.8	\$ 4.9	\$ 29.7	\$ 5.4
Geothermal energy	1.9	23.2	3.7	27.8	5.2	31.5	9.5
Coal energy	1.4	17.1	2.9	21.8	3.0	18.2	3.9
Hydrogen energy	1.2	14.6	1.5	11.3	1.5	9.1	1.9
Support research management, etc.	0.8	9.7	1.5	11.3	1.9	11.5	2.4
Total	8.2	100.0	13.3	100.0	16.5	100.0	23.1

Source: Sunshine Project Solar Photovoltaic Program and Recent R&D Activities in Japan, a paper presented by Yoshihiro Namikawa, Faculty of Engineering Science, Osaka University, Osaka, Japan, for the 1990 Photovoltaic Solar Energy Conference, Cannes, France, 27-31 October 1990.

a/Yen converted to U.S. dollars at each year's annual average exchange rate as shown in International Financial Statistics Monthly Report, July 1981, International Monetary Fund.

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TABLE 2. AMORPHOUS SILICON R&amp;D FUNDING RECIPIENTS, 1981.

<u>Industry groups</u>	<u>Government laboratories</u>	<u>Universities</u>
Sanyo	Electrotechnical Laboratories (ETL)	Tokyo University
Fuji Electric		Kyoto University
Mitsubishi		Osaka University
Kyoto Ceramic		Kanazawa University
Momatsu Denshi Kinzoku		Hirosshima University
Teijin Chemicals		Tokyo Institute of Technology

Source: Trip report, "Visits to Japanese Industries Involved in Amorphous Silicon Research and Development", Nov. 31, 1980 - Dec. 14, 1980, Jack Stone, Advanced Silicon Branch, SERI

JAPANESE MARKETING PLANS

Sanyo Electric is already producing and marketing amorphous silicon cells of rather low conversion efficiency (about 3 percent) which are used to power calculators, watches and toys. Earlier this year, Sanyo announced that it has now developed a 5 percent efficient amorphous silicon solar cell which it plans to use in a hybrid thermal/electric solar collector for the commercial market sometime in 1982.

During this review, officials of a number of U.S. companies said that the Japanese are preparing to enter the commercial market very soon. Most gave no specific details, but officials of one company that has done amorphous silicon R&D for DOE said that, based upon discussions with Japanese scientists visiting their plant, they believe that the Japanese plan to enter the U.S. commercial residential photovoltaics market as early as 1982.

In December 1980, the Director of the Advanced Silicon Branch, SERI, visited Japanese companies, universities and government laboratories that are engaged in amorphous silicon R&D and was shown a Sanyo factory being prepared to produce large amorphous silicon cells from three continuous process production lines. He told us that the Japanese industry and government have made a major commitment to penetrating the U.S. photovoltaic market and are concentrating on amorphous silicon technology. However, according to a JPL memorandum dated June 18, 1981, recent Japanese visitors indicated that a recent rumor that Japanese firms will produce amorphous silicon cells in 1982 for 65 cents per peak watt is unfounded.

In the United States, DOE has used the general guideline in developing amorphous silicon from the laboratory to commercialization, that the material would not be commercially viable until the conversion efficiency of amorphous silicon solar cells reached 10 percent. Hence, all of DOE's amorphous silicon programs to date have been R&D oriented. On the other hand, the Director, Advanced Silicon Branch, SERI, said that he believed that the Japanese were planning to move into commercial development of the technology when they reached a conversion efficiency of 7 percent. At the time of his visit to Japan, the Japanese amorphous silicon cells generally were up to 5 percent conversion efficiency and had reached a little over 6 percent under laboratory conditions. At that time, the best efficiency reached by a U.S. amorphous silicon cell was 7.19 percent.

At the International Photovoltaics Specialists Conference held in Orlando, Florida, in May 1981, a Japanese scientist claimed that Japan had achieved a conversion efficiency for an amorphous silicon cell of 7.55 percent. A Japanese Government official also claimed that a plant with a 10 megawatt ribbon-cell capacity could make cells 0.1 mm thick for only 12 cents per peak watt. Following the Orlando Conference, the Japanese delegation gave a Sanyo amorphous silicon cell to SERI for testing. SERI officials told us that the best conversion efficiency that they have been able to achieve with this cell has been only 6 percent, but they do not believe that the Japanese left their best cell (or type of cell). Other than this single cell, SERI officials said that the United States has not been able to corroborate any of the claims that Japan has made concerning amorphous silicon cell efficiencies, production capabilities or cost reduction progress.

#### Japanese marketing potential

Most U.S. company officials with whom we spoke said that the Japanese have not been a major competitor in the world photovoltaic market until now. Several DOE reports also confirm that Japan is not, at this time, a major market force. However, there are many Japanese companies which are either actively involved in photovoltaics production or which have the potential, based upon similar product lines, to enter the field very quickly. Most are very large companies with total sales ranging from \$1 billion to \$10 billion annually. Semiconductor sales, and, in particular, photovoltaic sales, make only a small fraction (2.3 to 17.8 percent) of the total sales of these companies.

Of these companies, some of the ones most noted in the trade journals for their technology development in photovoltaics appear to be Photoelectron Industries, Toshiba, Hitachi, Sharp, and Sanyo. Photoelectron claims to have produced 140 kilowatts (kw) of photovoltaics a year in 1979

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and 1980 and to have halved production costs since 1979 with the introduction of improved cell production methods. In addition, Photoelectron plans to build a \$1.4 million, 400 to 500-kw a year plant to be operating by the end of 1981.

According to the May 1981 issue of World Solar Market Journal, Toshiba is planning a \$3.6 million, 250-kw a year plant to make cells using its silicon ribbon process. It plans to make a 100-millimeter (mm)-wide ribbon, 0.5-mm thick, at a rate of 20-mm a minute with conversion efficiency of 9 percent.

Secondly, the article said that Toshiba claims to have produced, under laboratory conditions, 70 mm-wide ribbon at 25-mm a minute with cell efficiencies reaching 11 percent. A spokesman of the government's New Energy Organization claimed recently that Japan is constructing a plant with 10 megawatt ribbon-cell capacity which will be able to make cells 0.1-mm thick for 27,000 yen/kw--equivalent to only 12 cents per peak watt (compared with DOE's cost goal of 70 cents per peak watt by 1986).

Finally, World Solar Market claims Hitachi and Sharp are trying to reduce costs by improving production methods in other directions. They point out that Hitachi's labor accounts for 60 percent of cell production costs and it is experimenting with automatic processes, which it hopes to use in its planned 250-kw a year plant.

### Japan's international marketing network

The major Japanese semiconductor companies involved with photovoltaics have established affiliate companies in 22 countries, subsidiary companies in 9 countries, and branch offices in 51 countries. In the United States, Japanese companies use a variety of methods for product distribution. For example, Fujitsu sells through joint ventures, Hitachi and Nippon Electric Company sell through American firms as well as through their own sales subsidiaries, and Mitsubishi Electric Corporation established its own marketing facility. Other Japanese firms use direct sales, trading companies, and consortia for export marketing.

With this fully established marketing infrastructure throughout the world, some observers believe Japanese companies are prepared to immediately market photovoltaic technology at reasonable price levels are achieved. For instance, earlier, Sanyo already has a pilot plant producing amorphous silicon cells. This production, although small-scale, is extremely valuable experience. By way of comparison, Sharp currently produces amorphous silicon cells for the

## APPENDIX VIII

### COMPARATIVE DOE SOLAR ENERGY BUDGETS BY FISCAL YEAR

AS OF MARCH 1981

(BUDGET AUTHORITY)

Programs	FY 1980 appropri- ation ----- (note a) ----- (000)	FY 1981 appropri- ation ----- (note a) ----- (000)	FY 1981 rescission request			FY 1982 initial request ----- (note e) ----- (000)	FY 1982 revised request		
			Dollar in dol- lars ----- (omitted)	Reduction in dol- lars ----- (percent)	Reduction in per- cent ----- (percent)		Dollar in dol- lars ----- (000 omitted)	Reduction in dol- lars ----- (percent)	Reduction in per- cent ----- (percent)
<u>Energy supply research and development:</u>									
Active solar heating and cooling	\$ 56,900	\$ 40,700	\$ 38,400	\$- 2,300	- 5.7	\$32,500	\$11,500	\$- 21,000	- 64.6
Passive solar heating and cooling	27,950	31,700	30,200	- 1,500	- 4.7	31,950	10,300	- 21,650	- 67.8
Photovoltaics	150,045	154,200	133,200	- 21,000	-13.6	161,550	62,900	- 98,650	- 61.1
Solar thermal energy	b/151,200	133,750	115,700	- 18,050	-13.5	85,300	44,000	- 41,300	- 48.4
Biomass energy systems	33,000	42,500	27,200	- 15,300	-36.0	55,950	20,500	- 35,450	- 63.4
Wind energy systems	60,555	80,300	54,200	- 26,100	-32.5	73,600	19,400	- 54,200	- 73.6
Ocean energy systems	43,000	39,000	34,600	- 4,400	-11.3	36,750	-	- 36,750	-100.0
International solar energy program	-	12,000	10,800	- 1,200	-10.0	12,950	4,000	- 8,950	- 69.1
Solar information operating expenses	-	1,400	1,400	-	-	12,650	6,700	- 5,950	- 47.0
Solar energy research institute	6,900	5,000	5,000	-	-	23,800	-	- 23,800	-100.0
MX-renewable energy system	-	-	-	-	-	9,500	-	- 9,500	-100.0
Program direction	6,029	c/6,786	6,786	-	-	6,860	4,000	- 2,860	- 41.7
Technology support	3,100	-	-	-	-	-	-	-	-
Alcohol fuels	22,000	23,300	18,000	d/- 5,300	-22.7	32,600	10,000	- 22,600	- 69.3
<b>Subtotal</b>	<b>560,579</b>	<b>570,636</b>	<b>475,486</b>	<b>- 95,150</b>	<b>-16.7</b>	<b>575,960</b>	<b>193,300</b>	<b>-382,660</b>	<b>- 66.4</b>
<u>Energy production, demonstration and distribution:</u>									
Federal buildings	11,750	1,800	1,800	-	-	-	-	-	-
Market analysis	6,000	6,000	500	- 5,500	-91.7	6,750	-	- 6,750	-100.0
Program direction	736	740	740	-	-	740	-	- 740	-100.0
<b>Subtotal</b>	<b>18,486</b>	<b>8,540</b>	<b>3,040</b>	<b>- 5,500</b>	<b>-64.4</b>	<b>7,490</b>	<b>-</b>	<b>- 7,490</b>	<b>-100.0</b>
<b>Solar energy total</b>	<b>\$579,165</b>	<b>\$579,176</b>	<b>\$478,526</b>	<b>\$-100,650</b>	<b>-17.4</b>	<b>\$583,450</b>	<b>\$193,300</b>	<b>\$-390,150</b>	<b>-66.9</b>

a/Reflects FY 1981 congressional reduction of \$20.2 million.

b/Includes \$8.0 million for Barstow project which was deferred to FY 1981.

c/Does not include \$0.4 million pay cost supplemental.

d/Includes a \$2.5 million rescission for Ethanol from Biomass Facilities which was also proposed by the Carter administration.

e/Budget request as submitted by the Carter administration.

Source: Department of Energy, Congressional Budget Request FY 1982, Conservation and Solar Energy Program, Jan. 1981; Revised Congressional Budget Request FY 1982, Conservation and Renewable Energy Program, Mar. 1981.

APPENDIX IX

COMPANIES, ORGANIZATIONS, AND INDIVIDUALS CONTACTED

U.S. COMPANIES

Acurex Corporation  
Mountain View, California

Applied Research Technology of Utah, Inc.  
Salt Lake City, Utah

Applied Solar Energy Corporation  
City of Industry, California

AMETEK, Inc.  
Paoli, Pennsylvania

ARCO Solar Industries  
Los Angeles, California

Crystal Systems, Inc.  
Salem, Massachusetts

DSET Laboratories, Inc.  
Phoenix, Arizona

Energy Materials Corporation  
Harvard, Massachusetts

Exxon Enterprises  
New York, New York

Ford, Bacon & Davis Utah, Inc.  
Salt Lake City, Utah

Free Energy Systems, Inc.  
Holmes, Pennsylvania

General Electric Company  
Space Division, Solar Section  
Philadelphia, Pennsylvania

International Rectifier Corporation  
Semiconductor Division  
El Segundo, California

Lockheed Missiles and Space Company  
Palo Alto Research Laboratory  
Palo Alto, California

Martin Marietta Aerospace Company  
Denver, Colorado

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Microwave Associates, Inc.  
Burlington, Massachusetts

Mobil Tyco Solar Energy Corporation  
Waltham, Massachusetts

Motorola, Inc.  
Semiconductor Group  
Phoenix, Arizona

Photowatt International, Inc.  
Phoenix, Arizona

SES, Inc.  
Newark, Delaware

SILTEC, Inc.  
Menlo Park, California

Spectrolab, Inc.  
Sylmar, California

Spire Corporation  
Bedford, Massachusetts

Solectro-Thermo, Inc.  
Dracut, Massachusetts

Solenergy Corporation  
Wakefield, Massachusetts

Sollos, Inc.  
Los Angeles, California

Strategies Unlimited  
San Francisco, California

Solar Power Corporation  
Woburn, Massachusetts

Thermo Electron Corporation  
Waltham, Massachusetts

Varian Associates, Inc.  
Palo Alto, California

Westinghouse Electric Corporation  
Power Systems Company  
Advanced Energy Systems Division  
Pittsburgh, Pennsylvania

## APPENDIX IX

### INDIVIDUALS

Mr. Anthony Adler, President  
Solar Investors Associates  
New York, New York

Dr. Karl W. Böer  
Professor of Physics and Engineering, University of Delaware  
Member of Board of Directors, American Section, International  
Solar Energy Society  
Chief Scientist, SES, Inc.

Dr. Peter E. Glaser, Vice President  
Arthur D. Little, Inc.  
Chairman, SUNSAT Energy Council  
Editor, Solar Energy Journal

Mr. John V. Goldsmith, Vice President  
Solarex Corporation  
Rockville, Maryland

### U.S. GOVERNMENT ORGANIZATIONS

Department of Commerce  
Washington, D.C.

Department of Energy  
Washington, D.C.

Department of State  
Washington, D.C.

Department of Energy  
Denver, Colorado

Solar Energy Research Institute  
Golden, Colorado

U.S. Embassy  
Bonn, West Germany

U.S. Embassy  
Paris, France

U.S. Embassy  
Rome, Italy

### OTHER ORGANIZATIONS

Solar Energy Industry Association  
Washington, D.C.

COMES (The French Solar Energy Commission)  
Paris, France